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THE PRICE OF A FEW MINUTES' SLEEP

Air in Condensers

By H. Fothergill

SYNOPSIS—An analysis of the various ways in which air may get into condensers, preventing the maintenance of high vacuums, and suggested remedies.

While every engineer knows that air in a condenser is antagonistic to a high vacuum and high condensing efficiency, few realize the importance of it. The question of air in a condenser is not so vital to the reciprocating engine, but with the steam turbine, in which advantage is taken of the heat units in the steam at lower

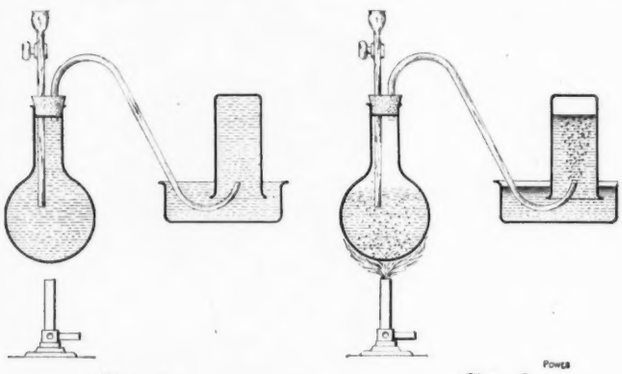

Fig. 1. Fig. 2.

Test for Percentage of Air in Water

pressures, to obtain such low pressure, or more generally called high vacuum, entry of air must be minimized.

To analyze the matter thoroughly it will be necessary to consider separately every way by which air can enter the system and ultimately reach the condenser so as to impair the vacuum. Beginning at the source of steam supply, the amount of air which enters a boiler depends upon the amount in solution in the feed water plus the amount added by the feed pump. The air in solution in the feed water varies considerably and depends upon the nature of the source of the feed make up, and the means for discharging the water of condensation from the condenser, which latter question will be dealt with later.

Feed makeup water, supplied from fresh-water tanks or water mains, is aërated from approximately 3 to 3½ per cent. of its volume, but it is easy to test the percentage of air in a feed water. The apparatus necessary, Figs. 1 and 2, consists of a flask connected to an inverted graduated jar, by a pipe, the jar being placed in a vessel in which the water is kept cool by any convenient means. The flask should be entirely filled with the sample of feed water and the glass jar also filled with water, as in Fig. 1; the water in the jar is preferably deaërated. Next heat is applied to the flask, as in Fig. 2, and boiling continued until the bubbles cease to rise, when the jar and beaker should be allowed to cool to the same temperature as at starting before taking any readings. The weight of the feed water from which the air has been driven off should be ascertained before commencing the experiment, so that the volume can be found. The volume of the air driven off is known by measuring the contents occupied by the air in the inverted jar; the percentage of air to the water by volume is equal to the volume of air driven off multiplied by 100, divided by the volume of water.

The amount of air added by a feed pump depends largely on the type of pump employed. With the old-fashioned, continuous-running, single-acting, plunger pump, the air passed through is a maximum, because the suction pipe of the pump may often be open to the atmosphere. But in modern feed pumps which are independently driven and have their action float-controlled so that the pump speed corresponds to the quantity of water to be dealt with, the suction inlet to the pump is always under water, and, therefore, the least air passes through, such air as does pass through being in solution in the water. Fig. 3 illustrates a convenient float-controlled boiler-feed pump. The tank from which the water is taken is immediately in front of the pumps and contains the float-controlling gear which is connected to the steam-supply valve by the balanced lever at the right side of the tank and the vertical rod. Whenever the water level in the tank falls below a predetermined limit, the steam supply to the pumps is reduced or cut off.

As the liberation of air from the feed water is greatest

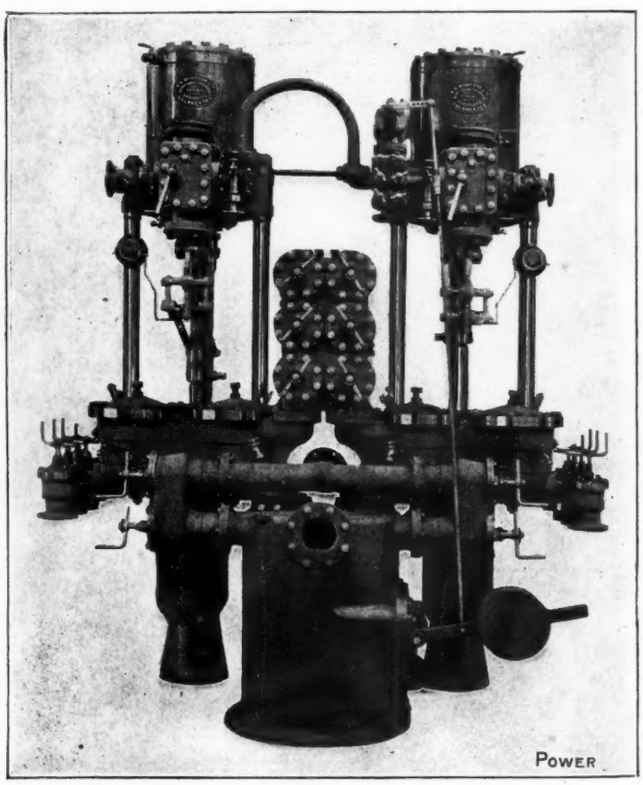

Fig. 3. Float-Controlled Boiler-Feed Pump

when the water approaches the boiling point, it is desirable that an air-liberating device be combined with a feed-water heater through which the water passes before entering the boilers and thus prevent as far as possible the admission of air with the feed water.

Fig. 4 shows a good combined heater and air extractor in which steam enters the central supporting pipe, and after passing through the distributing chamber, flows down through the double coils. The condensed water from the coils is discharged into a hotwell or feed tank. The feed water is heated by contact with coils of gradu-

ly increasing temperature and finally passes through the central discharge tube where it is in contact with the inlet steam pipe, the surface of which is of maximum temperature. The feed water on its upward course through the heater is rapidly raised in temperature, and on passing through the contracted area at the edge of the inverted cone, its upward velocity is so increased that the air bubbles are carried to the surface of the water in the dome where they are liberated and accumulate until the water level is forced downward enough for the float in the chamber connected to the heater to fall and open the air-discharge valve at the top.

Most generating stations have a float-controlled feed pump, or an air-collecting and discharging feed heater,

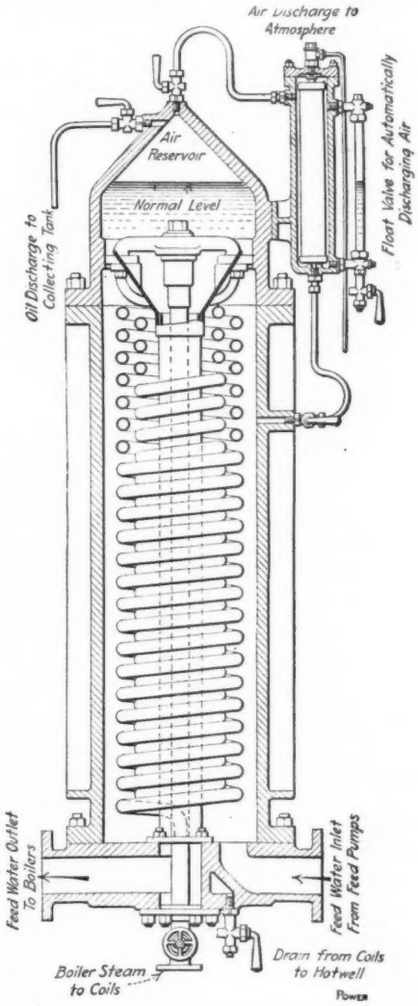
Air Discharge to Atmosphere
Air Reservoir
Normal Level
Float Valve for Automatically Discharging Air
Oil Discharge to Collecting Tank
Feed Water Outlet to Boilers
Feed Water Inlet from Feed Pumps
Boiler Steam to Coils
Drain from Coils to Hotwell
Power

FIG. 4. SECTIONAL VIEW OF SURFACE FEED HEATER

and sometimes both; so that little air enters a boiler with the feed water and thence passes with the steam into the condenser.

Investigation has shown that nearly all the air which enters a condenser is due to the leakage of joints and glands subjected to pressure less than that of the atmosphere.

Minimum air leakage is experienced when the steam-condensing and power-producing apparatus consists of a steam turbine having tight glands, few and accessible joints, and the connections to the condenser water sealed. Maximum air leakage is usually found in reciprocating engines, where numerous glands are subjected to a pressure lower than the atmosphere, and where auxiliary engines exhaust into the main condenser. In such plants the actual loss of power on the main unit by air leaking into the condenser through the auxiliary engines, is so great that it may exceed their total power, and, therefore, the auxiliary engines should exhaust into a separate condenser at atmospheric pressure or into an exhaust-steam feed-water heater. This possible loss in power on the main unit is caused entirely by the air drowning of the tubes in the condenser, which results in a reduced rate of condensation and a less perfect vacuum.

If a condenser could be had containing no air, the ideal condensing possibilities would be realized and the condensation of steam under vacuum would be very simple, as the heat transfer through the tubes from the

FIG. 5. CONTRAFLO CONDENSER

steam to the circulating water would be at a maximum for given conditions, thus producing the lowest temperature possible under such circumstances. Moreover, in the absence of air, the temperature throughout the condenser would be approximately the same, and no air pump or air-withdrawing device would be required. However, air being always present, it is necessary to consider how to keep the ratio of air in the condenser at a minimum.

Normally, when a condenser is under load, the air entering and leaving it in a given time is the same; but the ratio of air to steam in different parts of the condenser varies greatly. For instance, at the exhaust-steam inlet of a reasonably air-tight system the air to steam is so small that its effect is almost negligible. As the vapor passes through the condenser and the steam condenses, the percentage of air increases rapidly, until at the air-pump suction the air forms a very considerable proportion of the mixture. The weight of air in a condenser does not depend entirely on the capacity of the air pump, but to a very large extent on the design of the condenser. The high surface efficiency in all modern condensers is largely due to the absence of idle corners or pockets which would soon fill up with the air hanging around the tubes, as the transfer of heat and rate of condensation in such idle parts would be reduced to a minimum.

Another very important feature, which has only recently been emphasized and brought to the notice of engineers by D. B. Morison, is that the steam passing through the condenser should be so directed and guided that its kinetic energy is utilized in driving the air onward toward the air outlet. This feature with others, forms the basic principle of the new Contraflo Kinetic Condenser, the patents for which are owned by the Con-

traflo Condenser & Kinetic Air Pump Co., Ltd., of London. This condenser is of simple construction, as will be seen from Fig. 5, which illustrates a popular design now put forward.

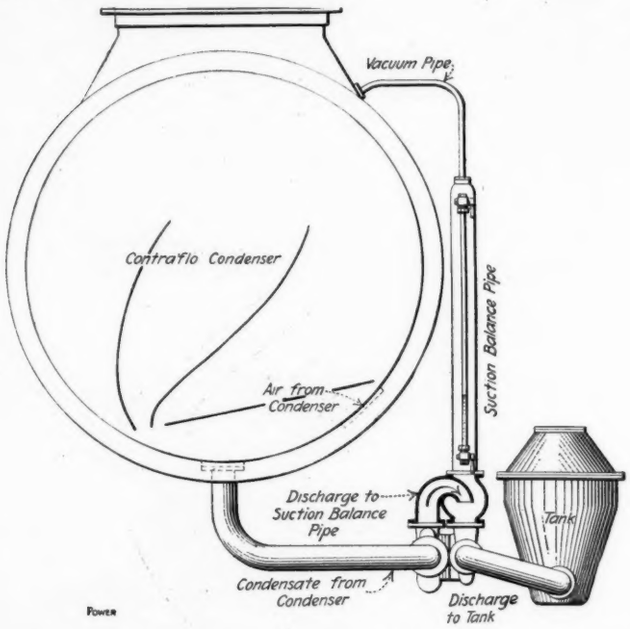

FIG. 6. DIAGRAMMATIC ARRANGEMENT OF TWO-STAGE PUMP DISCHARGING CONDENSATE TO TANK

The reasons which prompted this particular design were as follows: Experiment had shown that condensing efficiency is promoted in a surface condenser when the aërated steam is caused to pass over the condensing surface in a continuous current having uniform distribution and uniform direction of flow toward the outlet from the condensing chamber. It was known from previous experience that the insulation effect of the air particles

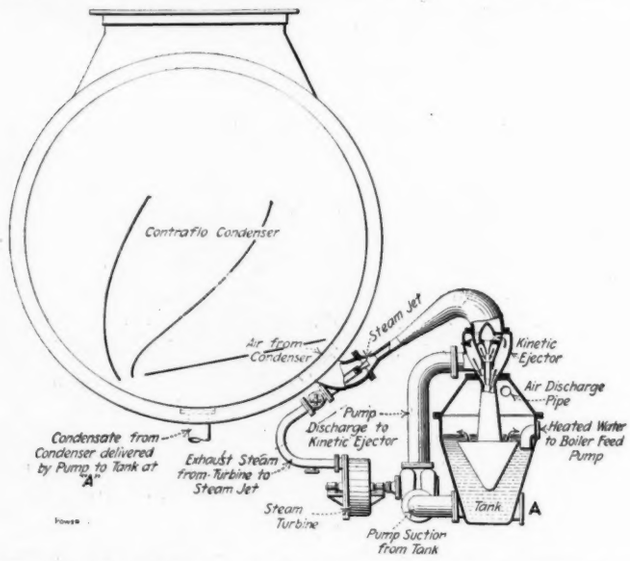

FIG. 7. DIAGRAMMATIC ARRANGEMENT OF KINETIC AIR EJECTOR FOR HIGH VACUUM

which impinge on the tubes at the steam entry is prejudicial to condensing efficiency, while at the exit the air density may be such as to render the tube surface practically inoperative for condensing vapor. Further, the fact was borne in mind that steam enters a condenser, as, for example, from a steam turbine, at a velocity of about 500 ft. per sec., and that at this velocity the kinetic energy of flow is considerable. As a consequence it was decided to direct the incoming steam by plates so as to pass over the condensing surface in a direction to promote stream lines of steam flow vertically or obliquely downward toward the air outlet. Thus the eddying of air particles in their passage through the condensing chamber is prevented and the kinetic energy of steam flow is utilized for, as it were, compressing the air into the air outlet and so assisting the air pump to withdraw the air from the condenser.

When water of condensation is withdrawn from a condenser with the air as by an air pump, it becomes highly aërated, but when withdrawn separately, it may be removed in a state of minimum aëration and delivered direct to the feed tank or feed pump.

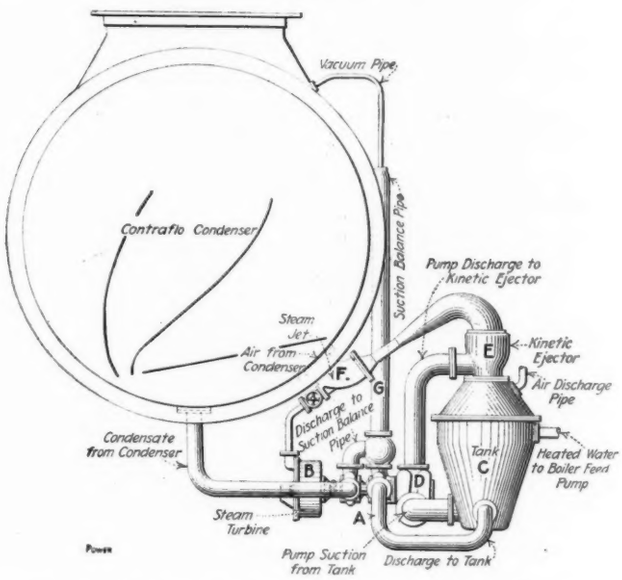

FIG. 8. DIAGRAMMATIC ARRANGEMENT OF KINETIC SYSTEM

Fig. 6 shows a rotary water-expelling device which is now being largely used in England. The apparatus consists of two pumps, the first or head pump discharging into a receiver that is connected to the second or pressure pump. This receiver is also connected to the condenser so as to provide a free escape for any air that may be carried into the receiver in suspension in the water. It will also be noticed that the discharge from the first pump is in the direction of the suction inlet to the second pump, so that the kinetic energy of the water discharged by the head pump assists its flow into the pressure pump. Before head and pressure pumps were adopted, removing the water from a condenser by a centrifugal pump required placing the pump some distance below the condenser to produce such a head on its suction side as would insure its satisfactory working. In the head-and-pressure-pump system the pumps may be practically on a level with the bottom of the condenser, the first pump producing the artificial head on the suction side of the second pump, thus avoiding need of room below the condenser which often is not available, especially on shipboard.

While describing this rotary system of water withdrawal, reference may be made to the Kinetic air pump with which such excellent results have recently been obtained. Fig. 7 shows the system diagrammatically and Fig. 8 the Kinetic air pump combined with the head and pressure pumps. In Fig. 8 the head and pressure pump *A* driven by the steam turbine, *B*, is removing the water from the condenser. This water—the boiler feed—is delivered into the tank *C*, from which it is withdrawn by the Kinetic pump *D* and is redelivered into the tank through the nozzles at *E*. The arrangement at *E* is the Kinetic ejector and is best seen in section in Fig. 7. Its function is to take hold of the mixture of steam and air coming from the ejector steam jet *F* and pass it into the tank *C*. The supply for the steam jet *F* is the exhaust from the turbine *B* and as this steam is condensed by the feed water passing through the water ejector *E*, the whole of the heat in the system is conserved in the feed water and can be returned to the boiler.

Several large installations based on the Contraflo Kinetic principles are under construction, including a large plant for Chicago, which has an overload capacity of 25,000 kw.

From the foregoing it will be seen that the question of air in high-vacuum surface condensers is one that must be considered by every engineer whether he be designing or superintending the running of a steam-condensing plant.

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Some Remarkable Examples of Soot

SYNOPSIS—Some interesting examples of soot formation on boiler tubes, due to lack of frequent blowing the tubes. It is shown that a suitable soot blower will reduce fuel consumption by keeping the tubes clean.

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In talking of soot, the average engineer is likely to think of a soft carbon deposit, such as is produced by a smoky lamp. That this impression of the character of soot that collects in boilers is widespread, is evidenced by the fact that in practically all articles and catalogs dealing with the subject of soot, the table from "Kent's Handbook," giving the heat-insulating values of different substances is invariably quoted. The figure for lampblack is then used to show the harmful effect of soot accumulations on boiler tubes.

As a matter of fact, the deposits on boiler tubes have a higher insulating value than lampblack because they increase the depth of the stagnant gas film.

Many engineers also seem to be under the impression that soot will only collect on boiler tubes when bituminous coal is burned. While it is true that soot, in the commonly accepted use of the word, is more likely to form on boiler surfaces when burning soft coal, the accompanying photographs prove that the deposits actually found on the outside of the tubes of water-tube boilers are composed of many substances besides soot and that practically all boilers, irrespective of the kind of fuel burned, are subject to these deposits.

The deposits shown in the illustrations are largely made up of ash carried by the draft and deposited upon the tube. They are also composed of inorganic matter from the fuel which volatilizes in the fire and then condenses when coming in contact with the comparatively cool tube.

When the deposits first occur the ash is in the form of a dust or powder, which can be easily removed, but if the deposit is allowed to accumulate there is a strong possibility that in time it will fuse together, producing some of the clinker formations, as shown.

Undoubtedly the formation of this clinker, which accumulates on top of the first layers of powdered matter, is because the deposit is allowed to become thicker. Its heat-insulating qualities become greater, therefore, the hot gases cannot come into contact with the cool tubes and finally the soot accumulation thickens until a temperature is reached which is sufficient to fuse the material on the top layers.

The sooty deposits found in modern boilers may be classified as: Molten slag, which forms as stalactites on the lower row of tubes when set close to the fire. It is not common and cannot be blown off. Clinker on top of the tube, Fig. 1, found only in the first pass, is a light porous clinker forming on top of the first deposit and shows how the first powdery deposit, which can be easily removed, will fuse together and clinker under the action of heat.

A cemented mass of clinker, Fig. 2, is found only in the lower rows of tubes of the first pass. The deposit is hard, brittle and porous. A scaly deposit is due to moisture in products of combustion cementing the ash deposit. It is frequently found throughout the boiler, Fig. 3. This deposit was taken from the first pass of a B. & W. boiler, using buckwheat coal, having about 16 per cent. ash content, hand fired. This deposit has the appearance of scale, it is white, soft and is made up almost entirely of ashes. The small cakes can easily be pulverized in the fingers, into a smooth, fine powder. It is noncombustible and cakes around the entire tube. It can be easily blown off.

The samples of soot illustrated herewith are not selected ones, but represent the general run of deposits found on boiler tubes. Many of the modern tendencies in boiler practice are conducive to the formation of deposits, such as those shown in the illustrations. One of these tendencies is the use of higher drafts, and the forcing of boilers at continuous overloads. High drafts take up the lighter noncombustible particles from the fire and carry them over and deposit them upon the tube. The more general use of stokers also produces the same result; that is, the burning of larger quantities of fuel per square foot of grate area. High rate of driving also produces higher gas temperature throughout the boiler, making fusing more probable.

One of the harmful effects of such deposits which up to the present time has not been fully appreciated, is that besides its direct heat-insulating value, the porous character of the deposit forms a large number of small cells which are active in retaining the gases of combustion and thus greatly increase the depth of the stagnant gas film around the boiler tubes, which has a marked ef-

fect upon reducing heat transmission. An experiment by Sir John Durston proved the temperature of the gas side to be 58 deg. higher than the water side. In other words, the entire loss of temperature from the 1600- to 2000-deg. temperature of the gases of combustion down to within 36 or 58 deg. of the water is due to loss through the gas film.

The formation of this porous clinker which is so effective in entangling the gases and increasing the depth of the film, also renders ineffective the scrubbing action of high velocity gases in removing the film, which is receiving so much attention at present. Furthermore, when this clinker gets thick enough to bridge over adjacent tubes it seriously interferes with the draft.

Although the first deposits are soft and in the form of powder which can easily be blown off, boilers are often installed with the only provision made for soot removal being a few small portholes in the side walls of the setting. Through these doors, some of them at a great height from the floor, the fireman is supposed to insert a perforated steam pipe and blow off the soot. This job is awkward, and as the pipe is hot, the job is shirked as much as possible. This method is also inefficient and primitive, as only the parts of the tubes near the blow doors are cleaned, the soot being blown away from these tubes to those more distant. In fact, no boiler 10 ft. wide can be cleaned by hand unless alley spaces at the side are unusually ample, thus wasting valuable floor space.

The most satisfactory method of thoroughly removing soot and ashes is by means of a suitable soot cleaner installed as part of the boiler equipment. As a result, even the tubes in the center are as effectively cleaned as those on the sides, or in the case of boilers set in batteries, the tubes on the far side are cleaned as thoroughly as those on the alley side.

The operation of such a cleaner is simple, as it is only necessary to open valves, and blow the soot from the tube surfaces. The boiler tubes can be blown frequently, say, once every watch, which is oftener than is ever done by hand. This method of blowing tubes does not reduce the furnace efficiency as no doors have to be opened, allowing infiltration of air. In one large plant now being installed, having 32 boilers, the blow doors are omitted entirely, thus doing away with the source of air infiltration which always reduces the CO_2 percentage.

To show that soot results in a higher temperature of gases from the boiler, the following figures were taken at one plant equipped with recording instruments. An average for one month's cleaning the tubes by hand gave a leaving temperature of 517.8 deg. and a CO_2 average of 11.2 per cent. A similar set of readings covering the same length of time when the boilers were blown every day with a soot cleaner gave a temperature of 391.8 deg. and a CO_2 average of 11.8 per cent. The CO_2 percentage is given merely to show that the efficiency of firing in both cases was practically the same.

FIG. 1. CLINKER FORMATION ON TOP OF TUBES

FIG. 2. CLINKER FOUND IN FIRST PASS OF LOWER ROW OF TUBES

FIG. 3. SCALY DEPOSIT CAUSED BY MOISTURE

Thus it is seen that with a soot cleaner the stack temperature averaged 126 deg. lower, corresponding roughly to a saving of 6 per cent. in fuel. Other tests have shown even greater savings. These savings are more than enough to pay for the soot cleaner in less than a year, and besides this must be added the greatly reduced cost for labor in cleaning the boiler over the hand method.

The samples of soot from which the accompanying illustrations were made were secured by engineers of the New York office of the Vulcan Soot Cleaner Co., to whom we are indebted for data contained herewith.

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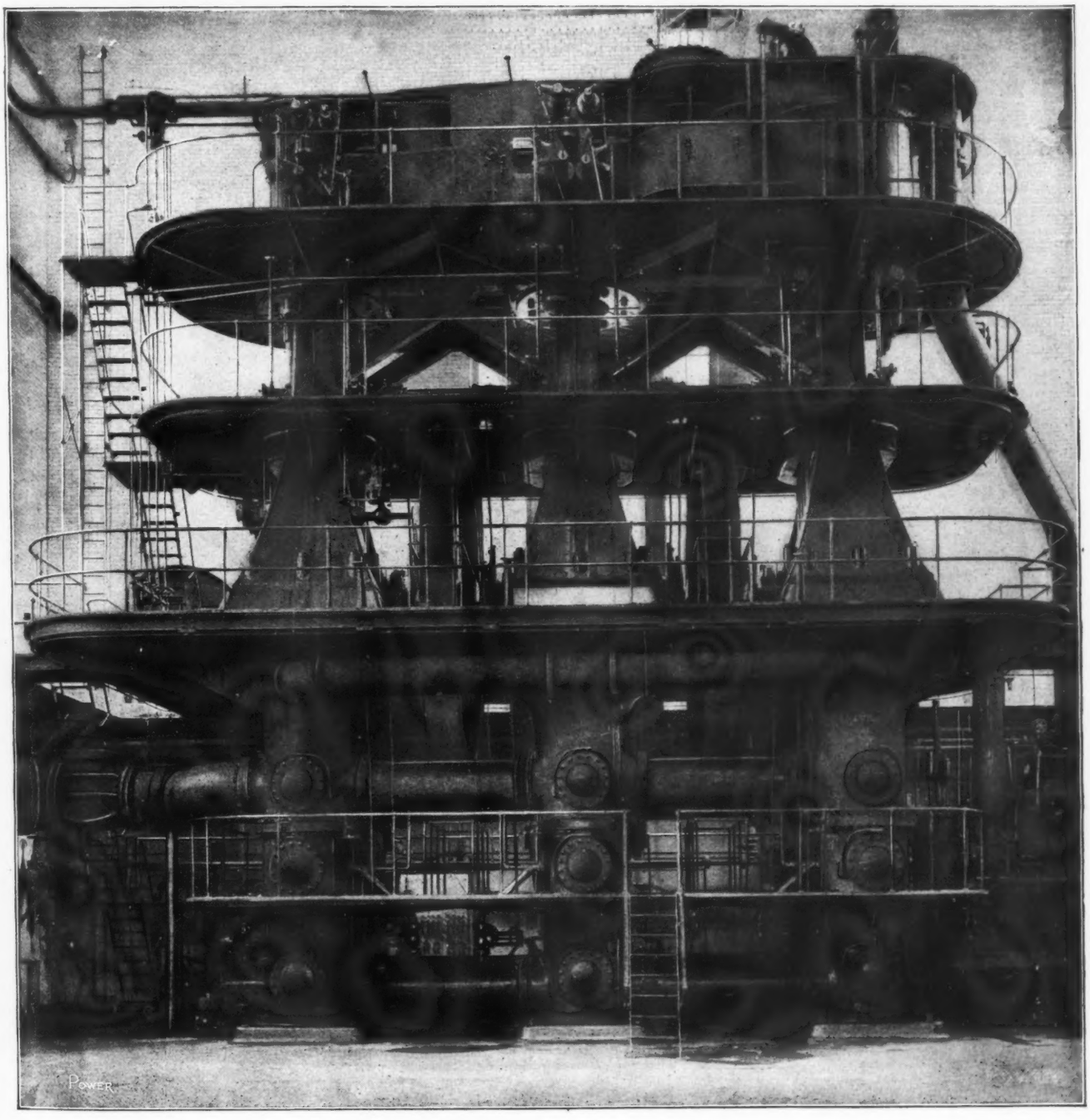
G. Rigg has investigated the causes of the deterioration of firebricks during use ("Journ. Ind. Eng. Chem.," p. 549, 1913), and concludes that other things being equal the resistance to the action of corrosive slags and gases is greater the more compact and close-textured the brick is. "Spalling" of close-textured brick is due to the use of unsuitable clay, or poor workmanship, or both. It is possible to prepare close-textured firebrick containing considerable amounts of coarse material, provided that sufficient care be taken in sizing the grog, so that the interstices between the larger fragments shall be filled as completely as possible by smaller fragments.

Pittsburgh's Large Pumping Engine



7,000,000-GAL. PUMPING ENGINE IN THE MISSION ST. STATION, PITTSBURGH WATER-WORKS SYSTEM

Herewith is a view of one of the pumps in the new Mission St. pumping station of the city water-works system of Pittsburgh, Penn. This engine is one of two vertical, triple-expansion, high-duty pumping engines built for this station by the Bethlehem Steel Co., Bethlehem, Penn., at a cost of $150,000. The engines pump against a head of 461 ft. and each has a guaranteed duty of 175,000,000 ft.-lb. per thousand pounds of dry steam supplied.

The other principal items in the equipment with their cost and by whom they were supplied are as follows:

Two water-tube boilers, $13,500. E. Keeler Co., Williamsport, Penn.

Electric-generating equipment, $2500. Dravo-Doyle Co., Pittsburgh, Penn.

Electric traveling crane, $4000. Northern Engineering Works, Detroit, Mich.

Steam piping, $7000, and feed-water heater, $1500. National Valve & Manufacturing Co., Pittsburgh, Penn.

Coal- and ash-handling apparatus, $7500. Scottdale Foundry & Machine Co., Scottdale, Penn.

Flue lining, $1700. H. W. Johns-Manville Co., New York City.

Oiling system, $2000. S. F. Bowser & Co., Fort Wayne, Ind.

Terry Return-Flow Turbine

SYNOPSIS—A new turbine in which a novel departure in the internal arrangement apparently solves the trouble from gland leakage.

A new multi-stage condensing turbine developed by the Terry Steam Turbine Co., Hartford, Conn., has several radical departures in details of construction. Fig. 1 is an exterior view of the turbine, Fig. 2, a view with the upper half of the casing lifted, exposing the rotor, and Fig. 3, a sectional elevation.

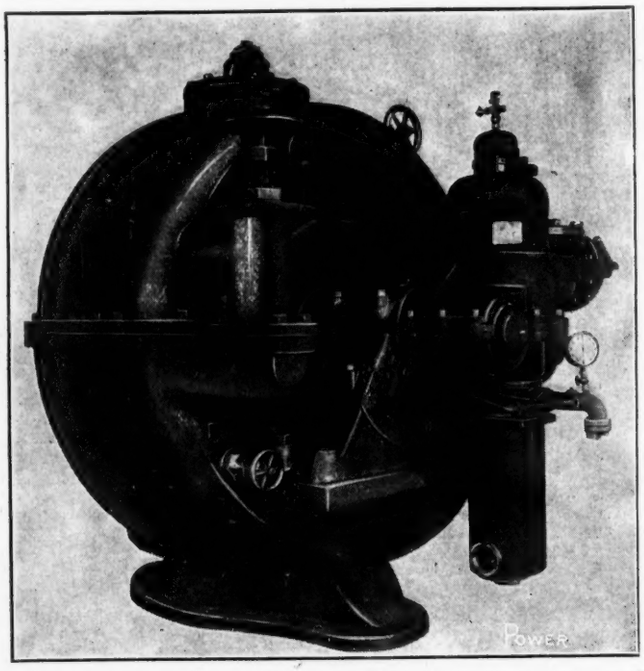


FIG. 1. THE TERRY RETURN-FLOW STEAM TURBINE

One of the new features is the arrangement for overcoming gland leakage, which will appeal to power-plant engineers who well know how difficult it is to locate air leaks in an exhaust system; the manufacturers of the condensing equipment blame it on the turbine glands and the turbine manufacturers invariably blame it on the condensing equipment.

In this machine the low-pressure element has been reversed. The steam, after coming to rest in the high-pressure element at a pressure slightly above atmospheric, flows through an ample passage, as shown in Fig. 3, to the opposite end of the turbine where it returns through the low-pressure element toward the high-pressure end. It is this feature that gives the turbine its name "return flow." The exhaust passage is in the center of the turbine, and the low-pressure gland, which ordinarily is exposed to the atmosphere, has, on its high-pressure side, a body of steam which forms an ideal seal, and what is more important, prevents the entrance of air.

The construction consists in general of a combination of two elements; the high-pressure element taking steam at boiler pressure and expanding it down to practically atmospheric pressure, and the low-pressure element further expanding the steam down to the condenser pressure.

The high-pressure element is identical with the standard single-stage machines manufactured for a number of years by the Terry company, except for refinements of design in the nozzles and stationary passages. As customary in the type the steam is expanded completely in diverging nozzles, the energy then being extracted by successive impulses on the wheel. The return buckets or reversing chambers are designed so that the steam enters both the buckets of the wheel and the reversing chambers themselves without shock.

After the steam comes to rest in the first stage it is led by a passage over the top of the turbine to the inlet of the low-pressure stages. These stages are of the action type, each consisting of a series of nozzles attached to a stationary diaphragm and discharging against a single row of moving blades. Each stage is designed to utilize the maximum amount of energy available by adiabatic expansion between the pressures at the entrance and the exit of the nozzles. After the steam leaves each row of moving blades (except the last) it is redirected into the inlet of the next set of nozzles so that the residual velocity is not destroyed in a series of eddies. The result is a higher overall efficiency than would be obtained were the steam allowed to come to rest after each action.

Ample blade area in the last wheel and low exit velocity reduce the carryover losses. Another feature of the low-pressure action elements is the nozzles with machined inner surfaces, which could not be so constructed were the nozzle plates cast in the diaphragms.

The turbine in general has the usual Terry characteristics, such as horizontally split casing, permitting the runner to be removed for examination without disturbing the steam or exhaust connections. The high-pressure element is of the usual Terry type and well fitted to cope with slugs of water should they get through the separator and the governor valve. Another advantage is

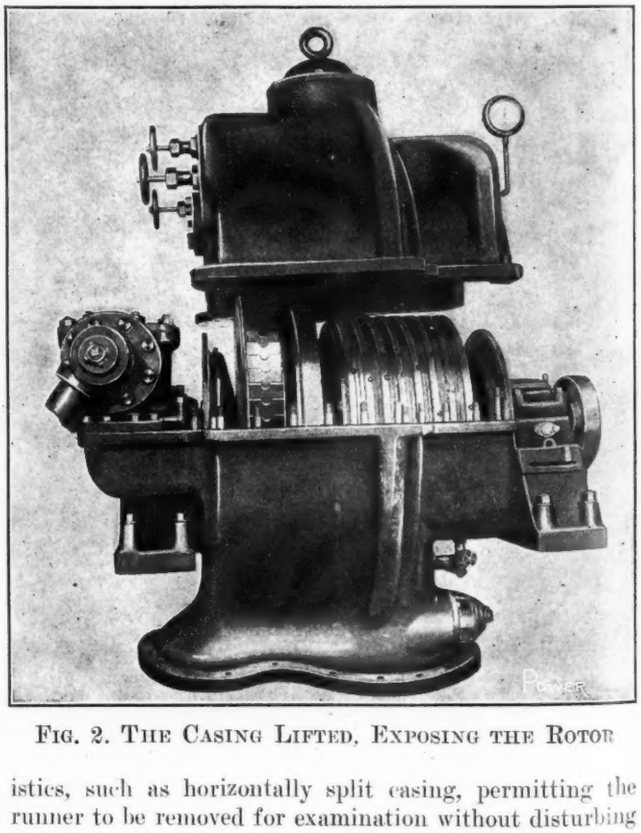


FIG. 2. THE CASING LIFTED, EXPOSING THE ROTOR

that in the high-pressure element large clearances can be used, for this is where the highest temperatures are found and, consequently, the greatest tendency to distortion. The machine is less subject to damage from starting up at short notice as the point at which the most danger exists when making a quick start from cold is at the high-pressure end, where the highest temperatures and the greatest temperature differences exist. This part of the machine being designed with large clearances and with the adjacent parts very heavy, even should rubbing occur, no serious results would be experienced.

The low-pressure element is self-contained and can be lifted out complete with the shaft. The low-pressure blading is mounted on segments that can be removed for inspection without disturbing the wheels or diaphragms.

The turbine casing is supported directly from the bearing pedestals, being attached by a cylindrical web close to the shaft. The plane of the pedestal feet is also close to the shaft so that trouble from change of vertical clearances when the machine is heated up, as well as dangers from casing distortion are minimized. The bearing housings proper are bolted to cylindrical seats in the pedestal webs. The actual surface in contact is narrow and there is considerable space between the bearing housing and the pedestal web, allowing an air circulation that reduces the amount of heat carried to the bearing-oil reservoirs by conduction.

The turbine-governor valve is made in a self-contained unit and embraces the main governor, which is fitted with adjustable and renewable seats, an emergency governor, and a steam strainer. The valve body is carefully designed to give ample steam-passage area as well as provide accessibility for inspection or adjustment. The turbine-casing glands are of the labyrinth type throughout, both between the low-pressure stages as well as at the point where the shaft leaves the casing. No soft packing metal is used in the turbine glands, nor are any lubricants required for any of the glands. It will be found that the outer glands have very little to do other than keep the steam inside of the turbine case, at about 1 lb. or 2 in. pressure, from leaking into the engine room.

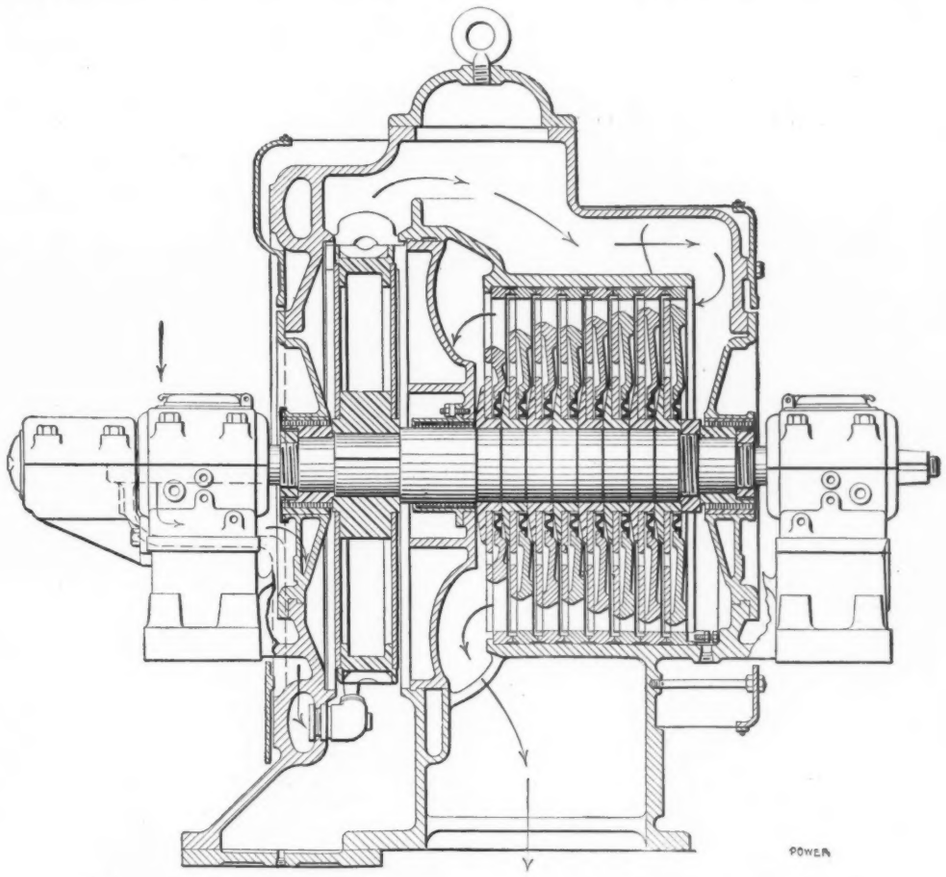
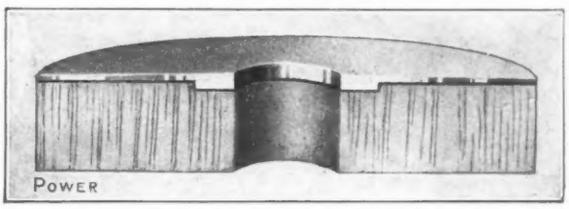


FIG. 3. SECTIONAL ELEVATION OF THE TERRY RETURN-FLOW TURBINE

Forced lubrication is provided throughout, as well as ring lubrication, which gives a dual system to cover any emergency.

Combination Pump Valve

This valve is made of a composition that will give under high pressure and temperature. In order, however, to prevent the flexible valve from cutting on the valve seat, a flat metallic disk of the same diameter as the nonmetallic body is used.



COMBINATION PUMP VALVE

As shown in the illustration, the center of the metallic disk fits in the counter-sunk portion of the valve disk, but is not attached to the valve other than by the fit in the counter-sunk portion. The metal disk is on the bottom side of the valve disk and its object is to resist wear when seating against the valve seat.

The valve is manufactured by the Peck Engineering & Manufacturing Co., 230 Milk St., Rochester, N. Y.

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Solutions for Absorbing CO_2, O and CO

By Charles M. Rogers

The methods here described for mixing reagents for the Orsat or similar hand flue-gas analyzers have been found very satisfactory.

Solution for CO_2

The most important constituent of flue gas to be determined for commercial work is carbon dioxide (CO_2). Its determination is effected by absorption in a solution of either caustic soda (sodium hydroxide, NaOH) or potash (potassium hydroxide, KOH). Of these two, the one most commonly used is KOH. A 33-per cent. solution is best adapted for this work, and is made as follows: Dissolve one part of KOH (stick form) in two parts of water, by weight, and allow to stand until thoroughly cooled before using. This will absorb from 35 to 45 times its own volume of CO_2. That is, if the pipette contains 150 c.c. KOH, it will absorb 5000 c.c., or 5 liters of CO_2. If the measuring burettes are graduated to 100 c.c., the pipette containing the solution prepared as above may be used to make 500 determinations averaging 10 per cent. CO_2 each time. Age has hardly any weakening effect on it. A complete absorption of CO_2 should not take over three minutes. The potash may be purchased from a druggist or dealer in chemicals. The chemically pure (c.p.) stick form is preferable for this work. Care should be taken in handling the caustic potash as it attacks the clothing and skin. The air has practically no detrimental effect on the solution, although it should be kept stoppered as there is a slight change to carbonate.

Oxygen Solution

The solution for absorbing oxygen (O) is not so easily made and requires more care than the caustic potash. Oxygen is usually determined by absorption with either phosphorous or alkaline pyrogallate. The latter will be given here as it is better adapted for use in an Orsat type of instrument, and accurate results may be obtained if proper precautions are taken.

It is well not to mix more than is needed to fill the absorption pipette, as a freshly prepared solution will give the best results, and there is less likelihood of its being spoiled by absorbing oxygen from the air. A good solution is made by dissolving 15 gm. of pyrogallic acid in 50 c.c. of water. The exact proportions are not essential. The pyrogallic will dissolve readily in the water without changing its appearance materially. This is then mixed with about 75 or 100 c.c. of the KOH solution prepared as given in the preceding paragraph for the absorption of CO_2. The solution turns to a very dark-brown color. As soon as the two are mixed the solution is ready for use and should be immediately transferred to the pipette in the Orsat, or placed in a dark-colored and tightly stoppered bottle. Pyrogallol will not spoil by exposure to air while in solution with water, but as soon as it is mixed with the KOH it becomes a strong reducing agent and should be used as soon after mixing as possible. The gas should be passed to and from the pipette about three or four times in 5 or 6 min. At the end of this time the oxygen should be completely absorbed. It is very important that the solution should be freshly prepared and made strongly alkaline by the KOH, as otherwise, carbon monoxide (CO) is likely to be given off as the oxygen is absorbed. This not only shows a lower oxygen but a higher CO.

The solution as prepared above will absorb about 5 or 6 times its own volume if used when freshly prepared; that is, one charge in a pipette should last for about 75 samples, each containing an average of 10 per cent. oxygen. If there is any doubt as to the strength of the reagent, an absorption of the oxygen in the air should be made, and if 20.8 per cent. is not readily obtained, a fresh solution should be made. The pyrogallic acid may be procured from any dealer in chemicals. It is a white, flaky powder and usually comes in tin cans or dark-colored bottles, and should be kept unexposed to the air.

Absorbing Carbon Monoxide

It is difficult to determine accurately the small percentage, if any, of carbon monoxide (CO) in the flue gas; and unfortunately its presence is of vital importance. The usual reagent for absorbing CO is an acid solution of cuprous chloride (Cu_2Cl_2). Enough to fill a pipette can be made by dissolving 22 gm. of Cu_2Cl_2 in 150 c.c. of hydrochloric acid (HCl) of specific gravity 1.12. The acid is only used as a solvent, as Cu_2Cl_2 will not dissolve in water, and, therefore, its exact purity is immaterial. The pure solution is colorless, but upon being exposed to air oxidizes and darkens. This weakens the solution but little, however. It can be kept colorless, or nearly so, by placing a bundle of copper wires in the container. If the oxidation is allowed to proceed until the solution becomes dark green, it should be removed. This solution will absorb less than one-half its own volume. When a sample containing a very small percentage of CO is brought in contact with cuprous chloride that has been used to nearly its capacity, the solution gives off CO instead of absorbing it. It is good to have a small pad or piece of slate tacked beside the cuprous-chloride pipette upon which the amounts of all the CO are tabulated, and when their sum exceeds the capacity of the solution, it should be replaced. The complete absorption should not require any more time than for the oxygen. About three washings in 7 or 8 min. are sufficient, according to the amount of CO. The average time required to determine the three gases, CO_2, O and CO, should not exceed 15 min.

❋

Chance is frequently at home in the boiler house, when it would not be allowed to enter the engine room, says "Power User," London. If an engineer were to run a heavily flywheeled engine at a speed which, by simple calculation, he could tell was very much too high, and the flywheel burst—where would his reputation and his job go to? Again, assuming he had discovered a suspicion of a fracture in his flywheel, would he be exonerated in the event of a smash, by saying he reduced his revolutions somewhat when he made the discovery? And yet, in the boiler house, where the uncertainty of things is vastly greater than in the engine room, things go on as they are.

ELECTRICAL DEPARTMENT

The Induction Motor—II

By F. A. Annett

Stator and Rotor Constructions

As explained in Part I, the induction motor consists essentially of two elements, a primary and a secondary.

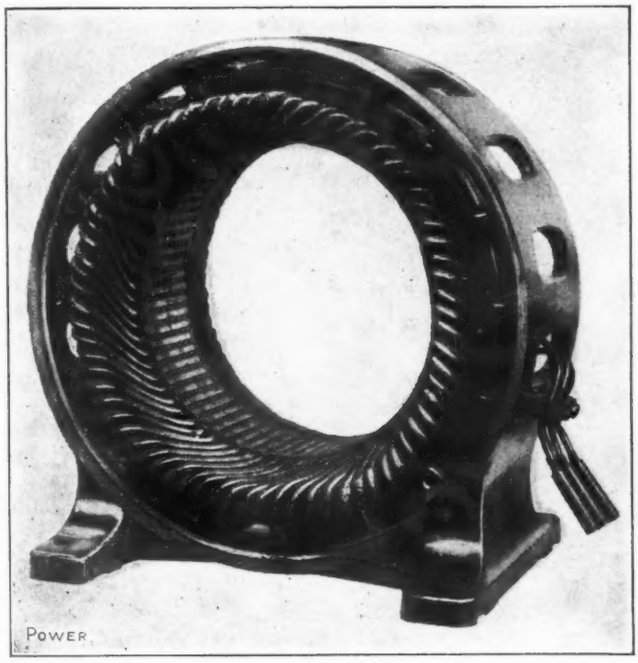


Fig. 7. Core-Frame Three-Phase Induction Motor

netic flux set up by the alternating currents in the stator winding, as was also explained.

Polyphase induction motors in most cases are built for two- and three-phase circuits and are of the squirrel-cage or wound-rotor types, depending upon the class of service for which they are intended. The squirrel-cage rotor type is used in places requiring practically a constant speed under varying loads where a large starting torque is not required, and where the large starting current at the low power factor required by the motor is not objectionable. The wound-rotor type should be used where a large starting torque is required and a heavy starting current is objectionable, such as starting motors on lighting circuits. This type can also be used for variable-speed service requiring practically a constant torque and where efficiency is of secondary consideration. The stator winding for both types is the same, the only structural difference is in the construction of the rotor, as will be explained later.

Five to ten years ago polyphase induction motors built by the various electrical manufacturers had about the same general appearance, but recent years have brought about many departures to improve the operating characteristics of the motor with a reduction in weight for a given output. This has been done by better proportioning of the slots and windings, improvement in the quality of laminated iron and steel used in the cores, better provisions for ventilating and improved methods of manufacture.

The stators of induction motors are built in three general types, the core-frame type, the skeleton-frame type and the riveted-frame type.

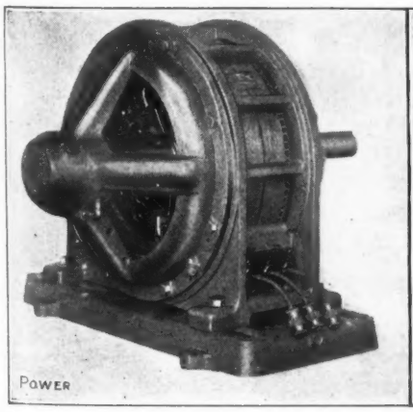


Fig. 8. Skeleton-Frame Motor

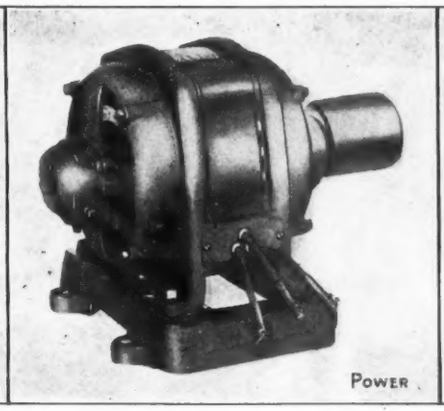


Fig. 9. Riveted-Frame Motor, G. E. Type

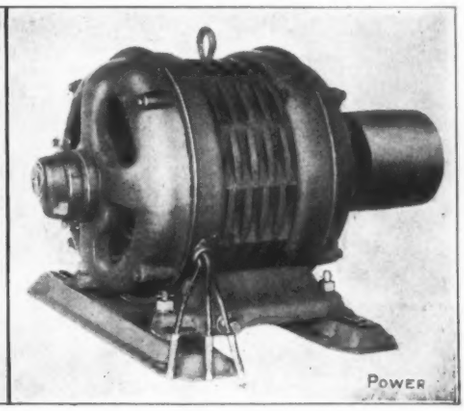


Fig. 10. Riveted-Frame Motor, Westinghouse Type

The primary winding which is connected to a source of alternating current is placed upon the stationary part of the motor, and is usually referred to as the stator; the secondary winding is placed upon the rotating part of the motor and is referred to as the rotor. The latter winding has currents induced in it by the action of the mag-

Fig. 7 shows the stator complete with its winding of an Allis-Chalmers core-frame-type induction motor. The laminated stator core is built up of high-grade electrical steel punchings which are carefully annealed and coated with an insulating varnish. This treatment is to reduce the core losses to a minimum. In the larger motors these

punchings are assembled in the stator frame with spacers introduced at intervals to form ventilating ducts through which currents of air are forced by the rotating member, thereby carrying off the heat from the interior of the machine. Lugs are cast on the inner surface of the frame

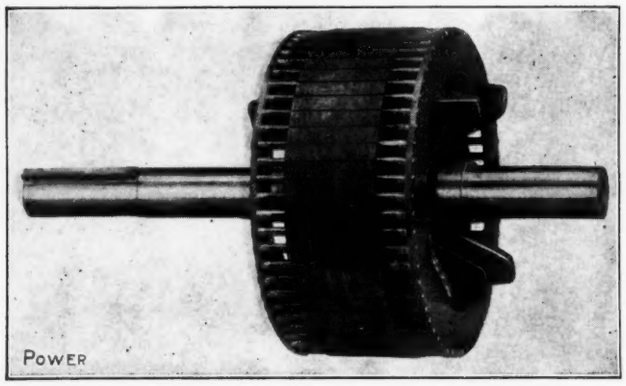


FIG. 11. ROTOR USED IN MOTOR OF FIG. 7

to support the stator core. A larger space is left between the frame and stator core and holes are cored in the frame which assists in making the motor run cool.

Fig. 8 shows a General Electric Co. skeleton-frame induction motor. It will be noted that all superfluous metal has been omitted, but at the same time the design has resulted in a frame that is stiff and rigid with considerable reduction in weight. The stator core is keyed to the frame ribs and held at each end by iron rings secured to the frame. This type is for sizes above 15 hp.

A General Electric Co. induction motor of the riveted-frame type is shown in Fig. 9. The cored frame usually employed to hold the stator punchings has been entirely eliminated and the weight of the motor is considerably decreased. The laminations are securely clamped between two cast-iron flanges or end plates while under hydraulic pressure. This construction is employed in small motors.

Fig. 10 shows a Westinghouse riveted-frame motor that is built in sizes from 1 to 200 hp. The laminations are riveted under hydraulic pressure between two pressed-steel end rings. The foot or base is of pressed steel and is securely riveted to the end rings. The particular formation of the laminations and the way they are assembled combines great strength with large radiating capacity.

The rotors of polyphase induction motors are built in two general types, the squirrel cage and wound rotor. The rotor core of a squirrel-cage-type induction motor is built up of steel laminations in a manner similar to the stator core. In small sizes the laminations are mounted on the shaft; in the larger sizes they are mounted upon a spider, the arms of which, in some cases, are shaped so as to act as fan blades. The rotor winding consists of a number of copper bars insulated with fiber, each placed in its individual slot and held in place by the overhanging tips of the teeth. In some cases insulating cement is used to insulate the bars in the slots.

One of the weak spots in the early squirrel-cage motors was the connection between the rotor bars and the short-circuiting end rings. From the effects of heavy strains and high temperatures the connections invariably worked loose. To overcome this defect, as well as improve other characteristics of the induction motor the manufacturers have devised the many methods of rotor construction.

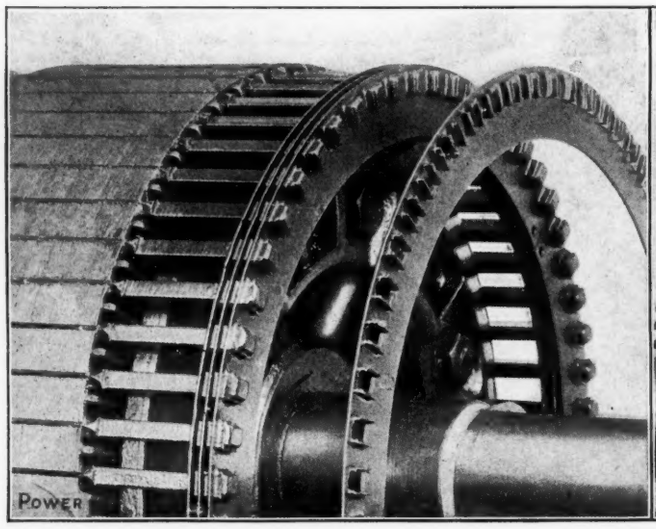


FIG. 12. ROTOR WITH BARS SHORT-CIRCUITED AT ENDS BY THIN RINGS

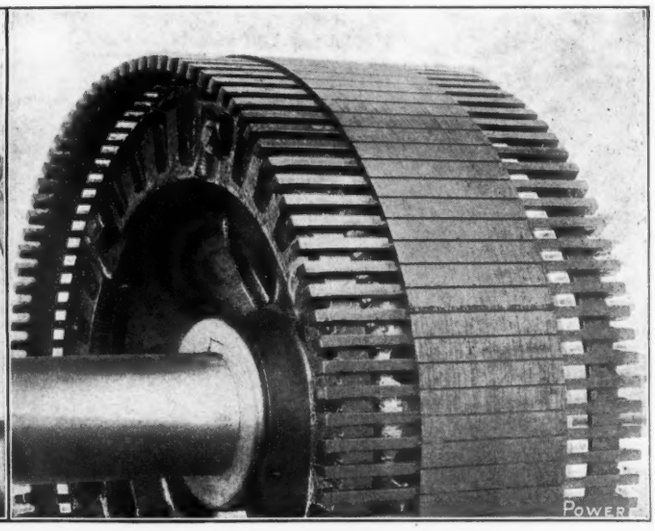


FIG. 13. SHOWING COPPER SHORT-CIRCUITING RING WELDED BENEATH BARS

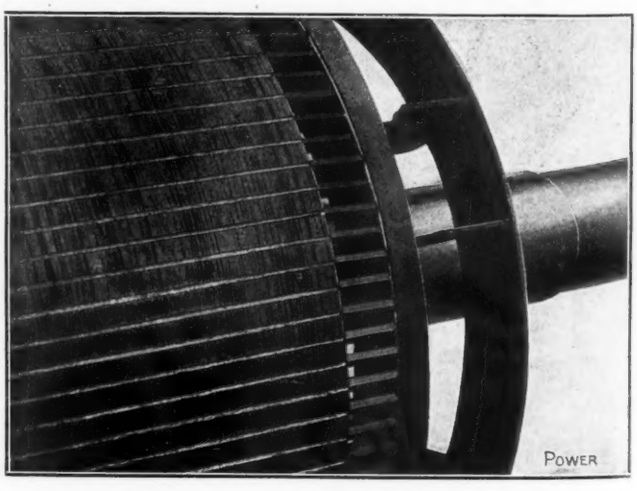


FIG. 14. ROTOR WITH CAST-ON END RINGS, WESTINGHOUSE TYPE

Fig. 11 shows the rotor used in the stator of Fig. 7. The short-circuiting rings, which are copper disks with holes bored in them near their outer periphery to receive

the ends of the bars, are set away from the end of the rotor core, thus allowing projections to be placed on the end of the core to act as fan blades. The short-circuiting rings, being away from the core, will dissipate heat much faster than if in contact with it and, therefore, will be much cooler for a given cross-section. The ends of the bars are turned down and then expanded into the holes in the disks, and, to prevent corrosion, are soldered.

Fig. 12 shows the type of rotor used in the smaller sizes of stators shown in Fig. 8. The bars are short-circuited at the ends by a number of thin rings. These end rings are of considerable radial depth and are held apart by projections formed on the ring itself when the rectangular holes are punched near the outer periphery; the projections also form ample area for soldering the rings to the bars. This multiple end-ring construction affords excellent ventilating facilities when the motor is in operation and the cross-section of the metal can be smaller than for a solid ring. The projecting ends of the bars improve the ventilation of the motor by drawing in currents of air and forcing it through the ends of the stator windings and ventilating ducts in the core. For the larger sized skeleton-frame motors shown in Fig. 8 a welded end ring is used as shown in Fig. 13; a cylindrical copper ring of sufficient cross-section is placed beneath the bars at each end of the rotor and then welded to each bar. This makes good electrical as well as good mechanical connections. The projecting end of the bars have the same effect in improving the ventilation as those in Fig. 12.

The rotor shown in Fig. 14 is used in the motor of Fig. 10. In this type the bars are insulated in the slots by a special insulating cement. In sizes above 15 hp. the end rings are cast on as shown, which results in good electrical as well as mechanical connection between the rotor bars and short-circuiting end rings.

An interesting example of rotor construction from a mechanical and electrical standpoint is represented in Fig. 15. The slots in the core instead of being parallel with the shaft as in the other types shown are diagonal. Instead of using the usual bar winding the rotor conductors are made by cutting a slit in a wide bar of copper and pulling this out into the familiar form of diamond-shaped coil. Fig. 16 shows the bar before and after forming such a coil; *a* is the copper bar with a slit cut in it and *b* the coil after it has been formed. This construction results in a permanent short-circuit of the rotor without the use of any bolted, riveted or soldered connection. This design is the product of the Burke Electric Co.

Fig. 17 shows the rotor of a Crocker-Wheeler induction motor. The end rings are made up of a helical arrangement of strips. In assembling these segments they are placed on the rotor bars in such a way that each one overlaps the one ahead of it, and in looking down on the rotor the rings have a helical appearance. It is claimed that this type of laminated end-ring construction has a better distribution of the current than where the end rings are made up of complete rings, for the inner rings tend to take more than their share of the current.

The rotor of a Fairbanks-Morse induction motor is shown in Fig. 18. The conductors are flat strips of copper placed on edge in the slots. This construction has made it possible to eliminate all insulation between the bars and the slots in the rotor core up to 75 hp. Above this size the bars are insulated with asbestos. The end rings are cast on at a temperature of over 1000 deg. C. After casting, the rings are turned down to size and an inspection groove is cut, as shown, to indicate that the fusion between the ring and bars is complete. The rotor bars have a Sirocco fan effect giving ventilation.

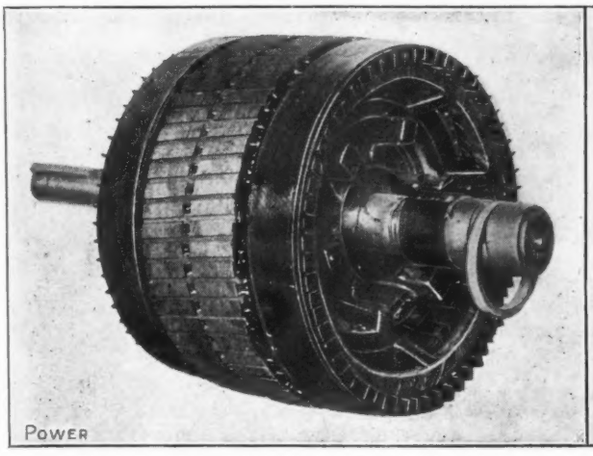


FIG. 15. SHOWING DIAGONAL SLOTS

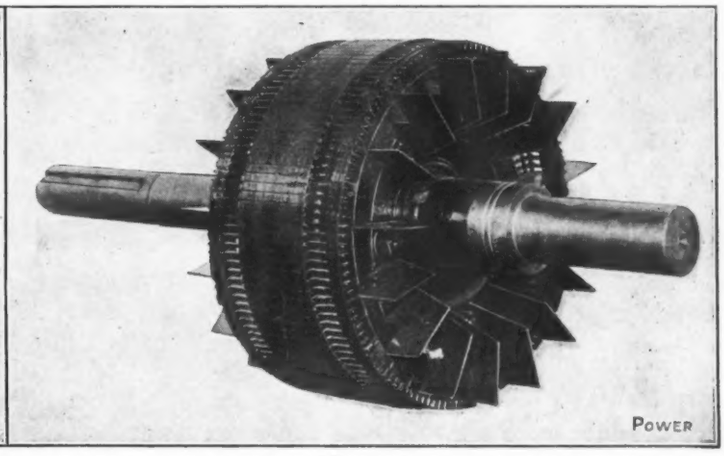


FIG. 17. END RING—HELICAL STRIP ARRANGEMENT

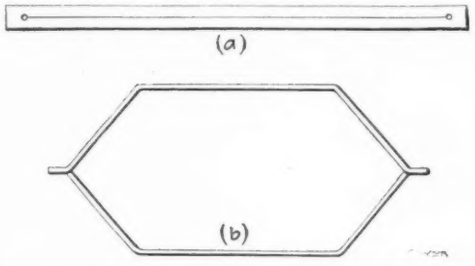


FIG. 16. BAR, BEFORE AND AFTER FORMING

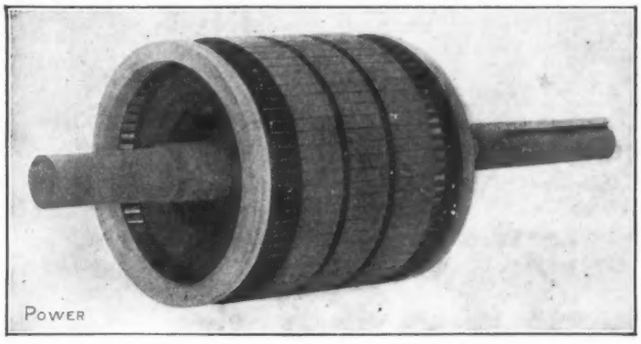


FIG. 18. ROTOR WITH CARBON END RINGS

GAS POWER DEPARTMENT

Compression Ratio vs. Efficiency

The effect of compression ratio on the efficiency of a gas engine as given in a paper by Professor Asakawa and J. E. Petavel before the British Association for the Advancement of Science, and reported in *Gas and Oil Power,* is stated in the following conclusions:

"The brake horsepower at full power increases in the same proportion as the theoretical air efficiency, so that the ratio of the two, or the relative efficiency, remains constant at about 55 per cent. Under light loads, the increase of frictional losses with high compression ratios nearly counterbalances the gain in thermodynamic efficiency; and, hence, while the absolute efficiency remains constant, the relative efficiency falls. At all loads, the mechanical efficiency is higher for low compression ratios. At full load, it fell from 79 to 74 per cent., as the compression ratio rose from 3.7 to 5.6; at one-quarter load it fell from 54 to 50 per cent. for the same change of compression ratio.

"The indicated power at full load increases at a higher rate than would be indicated by the air standard, and at light loads at the same rate. Hence the relative indicated efficiency increases at full load and remains constant at light loads. In the tests conducted on a 25-hp. engine and using gas having a lower calorific value of 520 B.t.u. per cu.ft. at 32 deg. F., the consumption at full power was 21 cu.ft. per b.hp.-hr. with the lowest compression; and 19 cu.ft. with the highest.

❖

The Motorship "Wotan"

Considerable interest was shown in the motor tankship "Wotan" of the Deutsche-Amerikanische Petroleum Gesellschaft which arrived at New York on Oct. 4, and after taking on a cargo of oil at the Standard Oil Co.'s docks, left again on Oct. 8.

Aside from being one of the largest motorships afloat the "Wotan" is propelled by the largest marine Diesel engine that has yet entered this port. This is a six-cylinder, two-stroke-cycle, Reichersteig-Carels engine with cylinders 23½ in. diameter by 43-in. stroke, and developing at 90 r.p.m., 2500 hp. At this propeller speed the vessel is driven at 10 knots per hour.

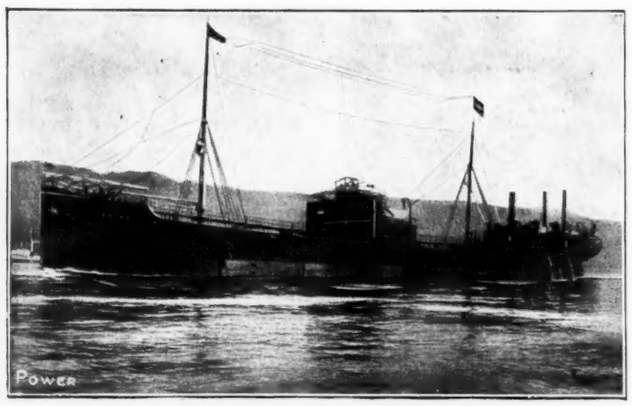


FIG. 1. MOTORSHIP "WOTAN"

In general appearance the engine follows very closely marine steam-engine design, aside from the cylinders and valves, of course. The cylinders are supported separately by columns, but are grouped in pairs, thus making a three-section crankshaft, each section of the same length, and thus making it necessary to carry only one spare length. There are two scavenging pumps driven by an oscillating beam from one of the main crossheads. Cooling-water pumps, bilge pumps and a compressor supplying air for the steering engine are similarly driven. Air for fuel injection is furnished by a three-stage air compressor on the Reavell principle, eccentrically driven from the crankshaft. This may be seen at the end of the engine in Fig. 2. An auxiliary air compressor of the same type is driven by a separate four-stroke-cycle engine.

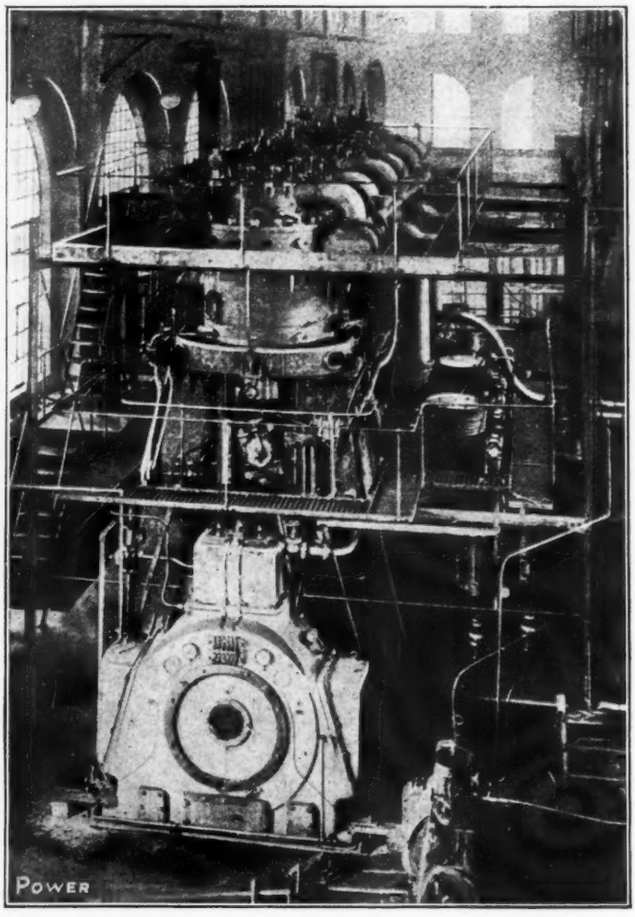


FIG. 2. ENGINE OF THE "WOTAN," SHOWING COMPRESSOR ON END OF SHAFT

The valve-gear is of the regular Carels design, there being four scavenging valves, one fuel valve and a starting valve to each cylinder. Reversing is effected by turning the camshaft through an angle of 30 deg.

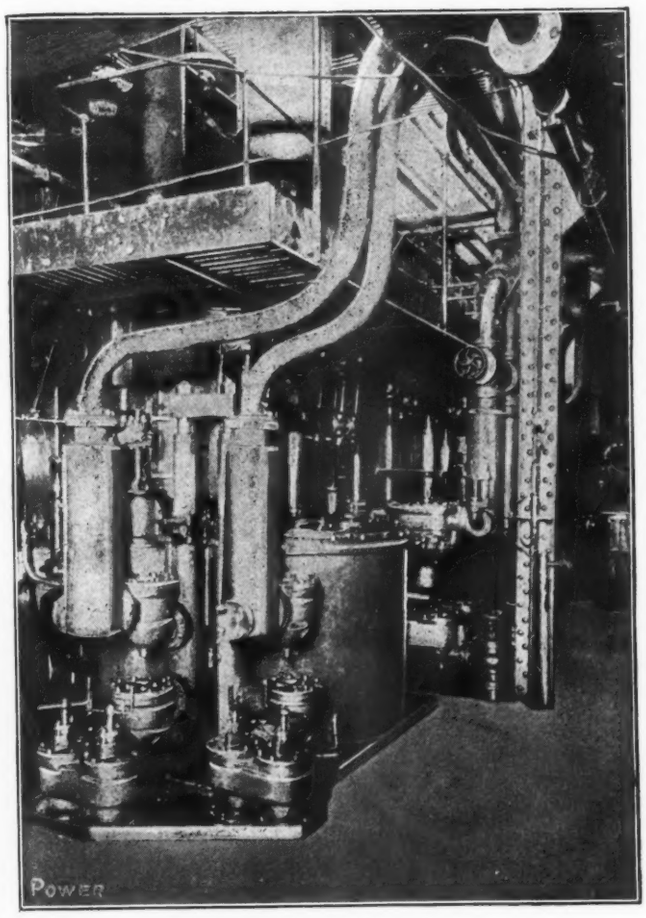


FIG. 3. SCAVENGING PUMPS

Among the auxiliaries there is a steam-driven compressor and two electric generators, one driven by a Diesel and the other by a steam engine.

At sea all auxiliary operations are intended to be performed by oil engines, compressed air or electricity, but for use while in port there is an oil-fired steam boiler to take care of the steering gear, the anchor hoists, windlasses and pumps. While this boiler is in service it also supplies steam for heating. At sea, heating is provided for by a small low-pressure boiler using coke for fuel.

Thoroughness in Purchasing Small Engines

The tendency of many purchasers of machinery to buy equipment in a haphazard manner is one of the chief causes of ultimately expensive service. There is a certain art about spending money efficiently, whether it be for a rug or for a gasoline motor, and the careful buyer who makes a thorough study of the important points to be covered in selecting a machine for a given duty is sure to be recompensed for the trouble such work entails. In buying a small engine, for example, many engineers are content with securing bids from well known manufacturers, calling for prices, guarantees as to performance and economy, and a statement as to the probable or promised date of delivery. This may be well enough in some cases, but what it means to buy an engine after a really thorough study of its features is well indicated by the following list of points recently included for the consideration of prospective bidders to supply an aeroplane engine for military service:

Light total weight, economy of fuel consumption, absence of vibration, smooth running, whether in normal or inclined position and whether at full power or throttled down; slow running under light loads, quality of workmanship, silence, absence of deterioration after tests, simplicity of construction, suitable shape to minimize head resistance, precautions against accidental stoppage, that is, dual ignition, adaptability for starting otherwise than by propeller swinging, accessibility of parts, freedom from fire risk, absence of smoke or of ejections of oil or gasoline, convenience in fitting in aeroplane, relative invulnerability to small-arm projectiles, economy in bulk, weight and number of minimum spare-part equipment, excellence of material, price, delivery and satisfactory operation under climatic variations in temperature.

H. S. KNOWLTON.

Cambridge, Mass.

Mechanical Efficiency of Gasoline Engines

The mechanical efficiency of any machine is the ratio of output to input. For a steam engine, gas or gasoline engine, this is obtained by dividing the brake horsepower by the indicated horsepower.

It may interest users of gasoline engines of the hit-and-miss type with constant gasoline level feed to know that the mechanical efficiency of such engines can be closely approximated without the use of a prony brake or indicator; simply count the explosions at full load and at no load.

When a gasoline engine is running at normal speed and zero load, fuel must constantly be injected into the cylinder to overcome the friction of the piston rubbing against the cylinder, the friction of the distributing shaft and bearings, the windage friction and the force necessary to suck the mixture into the cylinder. The quantity of mixture thus taken in is directly proportional to the number of explosions inasmuch as the same weight of gasoline is injected into the cylinder before each explosion. A gasoline engine of high mechanical efficiency will not explode as often when pulling zero load as will an engine of low mechanical efficiency.

For example, an engine that I once tested exploded 100 times per minute when pulling full load. With the load thrown off it exploded 20 times per minute. It is evident, therefore, that only (100 — 20) 80 explosions were used in doing useful work. Here 80 explosions are proportional to the brake horsepower and 100 explosions to the indicated horsepower. Hence, the mechanical efficiency of that particular engine was 80 ÷ 100 = 80 per cent. The formula for this method is:

$$Mech.\ eff. = \frac{N_e - N_o}{N_e}$$

Where

N_e = Number of explosions per minute when running at full load.

N_o = Number of explosions per minute when running at zero load.

Brooklyn, N. Y. S. F. WILSON.

REFRIGERATION DEPARTMENT

Comparative Installation and Operating Costs of a Combined Ice-Manufacturing and Cold-Storage Plant*

By R. H. Tait and L. C. Nordmeyer

The basis of this comparison is a plant having a capacity of 60 tons of ice per day of 24 hr., and a cold-storage capacity of 100,000 cu.ft. The cost of building and machinery equipment is figured three ways: First, with a simple steam plant; second, with a compound condensing plant; and, third, with the Diesel engine. The cold-storage space will require a refrigerating capacity of 20 tons, which is equivalent to 12 tons of ice-making capacity. The refrigerating machines and equipment must, therefore, be capable of developing the equivalent of 72 tons of ice-making capacity for 24 hr. daily.

In the latitude of St. Louis it has been found that if the output of the month of July is figured at full capacity, then the output in July is approximately 15 per cent. of the annual output. In the case under consideration, the yearly work is, therefore, equivalent to

$$\frac{72 \times 31 \times 100}{15} = 14{,}880 \textit{ tons of ice}$$

It is assumed that the plant would be erected in the Southwest, and fuel oil is figured at 95c. per bbl. of 42 gal. Artesian water is available at 87 deg. F. and city water at 90 deg. F.

Buildings

The cost of the buildings, including boiler and engine room, freezing-tank room, cold-storage house and all insulation will be approximately $60,000. The necessary building space will be practically the same for all three types of plant. The fixed charges against the building are for interest, 6 per cent.; insurance and taxes, 1½ per cent.; depreciation, 5 per cent., making a total of 12½ per cent. of $60,000, or $7500 per year. Inasmuch as 14,880 tons of ice represent the year's work, the building charge will be 50.4c. per ton of ice.

Simple Steam Plant

In this plant it is contemplated to use air lifts to pump the water from the artesian wells to furnish the necessary water for the plant in connection with a water-cooling tower. The mechanical equipment will include water-tube boilers, boiler-feed pumps, feed-water heater, smoke-stack, two 60-ton refrigerating capacity machines, ammonia-compression system, distilling system, freezing system, steam and exhaust connections, air lifts and air compressor, circulating-water pumps, cooling tower, piping for cold-storage rooms, brine pumps, brine cooler, all steam, brine and ammonia pipe covering, 60-kw. generator and engine, ammonia, calcium and foundations for machinery. It is estimated that the complete equipment, delivered and erected, including engineers' fees, will be $65,000. The total cost of the plant, including building and machinery, will, therefore, be $125,000. The auxiliary pumps about the plant will consist of duplicate units, one steam-driven and one electrically driven.

It is estimated that there will be burnt 3.08 bbl. of oil per hour under the boilers when operating at full capacity. With oil costing 95c. per bbl. and the capacity being 72 tons ice making, the fuel cost per ton of ice will be

$$\frac{3.08 \times 95 \times 24}{72} = 97.6c.$$

The operating cost is estimated as follows:

Two firemen at $720 per year	$1440
Two engineers at $1230 per year	2460
Two oilers at $720 per year	1440
One handy man	900
Oil, waste, etc.	300
Total	$6540
$\frac{\$6540}{14{,}880}$ =	$0.439 per ton of ice
Ice handling	0.14 per ton of ice
Total operating expense	$0.579 per ton of ice

Fixed charges on the mechanical equipment are for interest on machinery investment, 6 per cent.; insurance and taxes, 1½ per cent.; depreciation and obsolescence, 5 per cent., making a total of 12½ per cent. on $65,000 or $8125. Fixed charges per ton of ice are then

$$\$8125 \div 14{,}880 = \$0.546$$

The total cost per ton of ice is given in the following:

Fixed charges	$0.546
Fuel	0.976
Operating expenses	0.579
Total	$2.101
Fixed charges on building	0.504
Total cost	$2.605

Attention is called to the fact that the total cost of ice, as given above and in the later deductions, is higher than the actual cost of ice at the platform, owing to the fact that the fixed charges on the machinery and building include the fixed charges on the brine cooler, brine pumps, cold-storage house piping, cold-storage house building and insulation which should be properly charged against the cold-storage house only. As these are the same in each case considered, the costs given in each case will not affect the comparison. As the ammonia cost will depend on the care given the plant, and should be the same for each, it has not been used in the estimated cost per ton in making the comparison.

Compound Condensing Steam Plant

In this plant the water will be pumped from the artesian wells in the same manner as in the simple steam plant. The engines on both of the refrigerating machines and on the generator will be compound condensing. The boilers will be equipped with economizers, so that the best efficiency may be obtained in the complete plant. The complete cost of the mechanical equipment, including engineers' commission, is estimated at $76,400.

When operating under full load there will be consumed

*Paper read before the Third International Congress of Refrigeration.

2.38 bbl. of oil per hour, making the fuel cost $2.26 per hour, or $0.753 per ton of ice. The operating expenses for labor, oil, waste, etc., will be $0.579 per ton of ice, the same as for the simple steam plant. The fixed charges against the investment will be

$0.125 \times \$76,400 = \$9550 = \$0.642$ *per ton of ice*

The total cost per ton of ice is, therefore, given in the following:

Fixed charges	$0.642
Fuel	0.753
Operating cost	0.579
Total without building charge	$1.974
Building charge	0.504
Total cost	$2.478

The complete cost of plant is as follows:

Cost of machinery	$76,400
Cost of building	60,000
Total cost	$136,400

Diesel Engine Plant

In this plant city water will be used for the making of raw-water ice and for the cooling-tower make-up. All auxiliaries around the plant will be driven by electric current. Power will consist of two 225-b.hp. Diesel engines, to each of which will be belted one 60-ton refrigerating capacity machine and one 40-kw. generator. The complete mechanical equipment will consist of two 225-hp. Diesel engines, two 40-kw. belted generators, switchboard, two 60-ton refrigerating capacity belt-driven refrigerating machines, compression system, raw-water ice-freezing system, cooling tower, two centrifugal water-circulating pumps, cold-storage piping, two triplex brine pumps, brine cooler, brine and ammonia pipe covering, ammonia, calcium chloride, two oil tanks, foundations for refrigerating machines, Diesel engines, etc. It is estimated the complete equipment will cost $83,923, including engineer's commission.

The fixed charges against the mechanical equipment will be as follows:

Interest on investment	6 per cent.	
Insurance and taxes	1½ per cent.	
	7½ per cent. of $83,923	= $6294
Depreciation and obsolescence on oil engines	10 per cent. of $34,440	= $3444
Depreciation and obsolescence on remainder of machinery	5 per cent. of $49,483	= $2474
Total		$12,212

The fixed charges per ton of ice equal

$$\$12,212 \div 14,880 = \$0.821$$

When operating at full capacity the power required by the refrigerating machine is estimated to be 282 b.hp. at the Diesel engine and for the electric units 97 b.hp., making a total of 379 b.hp. at the engine. Assuming an oil consumption of 8 gal. per 100 b.hp.-hr. there would be consumed 30 gal. of oil per hour, making the fuel cost $16.30 per day, or 22.6c. per ton ice-making capacity. The operating expenses will be as follows:

Two engineers at $1230 per year	$2460
Two oilers at $720 per year	1440
One handy man	900
Oil, waste, etc.	800
Total	$5600
$5600 / 14,880 =	$0.376 per ton ice
Ice handling	0.14 per ton ice
Total operating cost	$0.516 per ton ice

City water must be supplied for making 60 tons of ice and for supplying the losses of the cooling tower. For this purpose there will be used 263,500 cu.ft. of water per month.

70,000 cu.ft. of water costs	$64.15
193,500 cu.ft. of water at 7c. per 100	135.45
Total water cost per month	$199.60
Water costs per ton of ice	$0.09

From the above the total cost per ton of ice is as follows:

Fixed charges	$0.821
Fuel	0.226
Operating expense	0.516
Water	0.090
Total without building charge	$1.653
Building charge	0.504
Total cost per ton of ice	$2.157

The total cost of the plant will be as follows:

Cost of machinery	$83,923
Cost of buildings	60,000
Total cost	$143,923

Résumé

The comparative cost of installation and operation of the three types of plant is given in the accompanying table:

COMPARATIVE INSTALLATION AND OPERATING COSTS

	Simple Steam Plant	Compound Condensing Steam Plant	Diesel Engine Plant
Cost building	$60,000	$60,000	$60,000
Cost machinery	65,000	76,400	83,923
Total cost	$125,000	$136,400	$143,923
Cost water per ton ice	.....	.....	$0.09
Cost fuel per ton ice	$0.976	$0.753	0.226
Fixed charges machinery	0.546	0.642	0.821
Operating cost	0.579	0.579	0.516
Cost per ton ice without building charge	$2.101	$1.974	$1.653
Building charge per ton ice	$0.504	$0.504	$0.504

From the table the following comparisons can be deduced:

Simple vs. Compound Steam Plant: The compound condensing steam plant costs $11,400 more than the simple steam plant, but a saving of 12.7c. per ton of ice is accomplished, which for 14,880 tons of ice-making capacity per year amounts to $1889.76 per year. On this basis the compound condensing steam plant will pay for the difference in cost between it and the simple plant in approximately six years.

Simple Steam Plant vs. Diesel Engine Plant: The Diesel engine plant will cost $18,923 more than the simple steam plant, but a saving is accomplished of 44.8c. per ton of ice, or $6666.24 per year. On this basis the Diesel engine plant will pay for the difference in cost between it and the simple steam plant in less than three years.

Compound Condensing Plant vs. Diesel Plant: The Diesel engine plant costs $7523 more than the compound condensing steam plant, but a saving of 32.1c. per ton of ice is accomplished, which amounts to $4776.50 per year. From this the Diesel engine plant will pay for the difference in cost between it and the compound condensing steam plant in less than two years' time.

From the comparison given above, it seems apparent that the oil-engine plant would be an exceedingly good investment. This should especially be apparent on account of the manner in which the deductions were made. The steam-driven plants were given the benefit of the best efficiency that could be obtained; namely, a boiler efficiency in the case of the simple plant of 65 per cent.; and in the case of the compound condensing steam plant, with the use of an economizer, of 71½ per cent.

The steam consumption of the simple engine of the refrigerating machine was assumed to be 27 lb. per i.hp.-hr., while that of the electrical generators was assumed to be 30 lb. of steam per i.hp.-hr.

In the case of the compound condensing steam plant, a steam consumption of 18 lb. per i.hp.-hr. was assumed for the steam engines of the refrigerating machine, and 20 lb. per i.hp.-hr. for the generator engines, including steam for vacuum pumps and other auxiliaries.

In the oil-engine plant, the engines were credited with a low efficiency of 8 gal. per 100 b.hp.-hr., while it has been found that the fuel consumption of engines installed in the Southwest by the Busch-Sulzer Bros.-Diesel Engine Co. was approximately 6½ gal. per 100 b.hp.-hr. under normal working conditions. In addition to this, the oil-engine plant is charged with water bought from the city, as against artesian-well water used in the steam plant.

A further advantage is given the steam installations by charging them with a depreciation and obsolescence of only 5 per cent. as against 10 per cent. charged to the Diesel oil-engine installation.

The present prices of fuel oil will somewhat change the figures, as shown, but cannot help but prove the oil engine a good investment.

Latent Heat of Fusion of Ice

At the Third International Congress of Refrigeration, in Chicago, H. C. Dickinson, D. R. Harper and N. S. Osborne presented a paper on the above subject, which included a review of previous work and a discussion of the methods used and results obtained by the Bureau of Standards, Washington, D. C. The determinations of the heat of fusion of ice, up to the year 1870, as reviewed by A. W. Smith, are given in Table 1. As may be observed, there is great variation among the results. Many of them were based on but few experiments, and with little doubt were carried out under conditions less favorable than for those made more recently. A summary of the results of the most important determinations subsequent to 1870 is given in Table 2.

TABLE 1. RESULTS OBTAINED UP TO 1870

Name	Date	Number of Experiments	Temperature Range of Water	Heat of Fusion, Calories per Gram	B.t.u. per Lb.
Black	1762	2	80–0	79.7	143.5
Wilke		1	72–0	72	129.6
Laplace and Lavoisier	1780	2	100–0	75	135.0
Provostaye and Desains	1843	17	24–10	79.1	142.4
Regnault	1842	4	16–7	79.24	142.6
Regnault	1843	13	22–11	79.06	142.3
Hess	1848	40	19–7	80.34	144.6
Person	1850	6	16–5	80.0	144.0
Bunesn	1870	2	100–0	80.02	144.0

TABLE 2. RESULTS OBTAINED SUBSEQUENT TO 1870

Name	Date	Number of Experiments	Heat of Fusion, Calories per Gram	B.t.u. per Lb
Smith	1903	8	79.59	143.3
Bogojawlensky	1904	6	79.61	143.3
Behn (calculated by Roth)	1905		79.69	143.4
Dietericil (calculated by Roth)	1905		79.60	143.3
Mean			79.62	143.3

By the Bureau of Standards, the heat of fusion of 92 individual ice samples has been determined by either the electrical method or the method of mixtures, both of which are thoroughly explained in the paper. Of these the first 50 determinations were made on samples cooled in cryostats antedating those described in the paper, in which the temperatures and the distribution of temperature were not so well known. These observations, which include commercial plate, can and natural ice, as well as ice frozen in the laboratory from double-distilled water, both free from air and containing air, showed no difference greater than one part in a thousand in the heat of fusion for these various samples. However, on account of the uncertainty in the initial temperature of the ice, the results were omitted from the paper.

Four observations on samples of ice artifically contaminated with a mixture of equal parts of ammonia, sodium chloride, and calcium chloride, to the extent of about one part in a thousand, gave results about 1.4 per cent. lower than for pure ice. From the remaining observations the results may be summarized as follows:

Five observations by the electrical method on samples of commercial plate ice gave for the heat of fusion 79.65 calories per gram mass, with a mean variation of 0.02 calorie.

Five observations by the electrical method on commercial can ice gave 79.65 calories per gram mass, with a mean deviation of 0.02 calorie.

Eight observations by the method of mixtures on commercial can ice gave 79.61 calories per gram mass, with a mean deviation of 0.02 calorie.

Five observations by the electrical method on Maine natural ice were made, of which three were consistent with each other and with other results, while two differed so much from the other results as to justify their omission. The three determinations gave 79.65 calories per gram mass, with a mean deviation of 0.01 calorie.

The mean of the results by the electrical method is 79.65 calories if the ratio of the calorie to the joule be taken as 4.187.

The mean of the results by the method of mixtures is 79.61 calories, independently of the ratio of the joule to the calorie.

The mean of the 21 observations gives for the heat of fusion of ice 79.63 calories per gram mass, or approximately 143.5 B.t.u. per lb., weighed in air against brass or iron.

In another paper before the congress, A. Leduc, professor at the Faculty of Sciences, Paris, after a review of previous work and a discussion of the possible causes of error, decided that a value of 79.6 calories could be taken as the latent heat of fusion of ice with an error less than one in a thousand.

The second section of the congress proposed that the value 143.5 B.t.u. per lb. be adopted as the universal standard for the latent heat of fusion of ice, but as far as we are aware no action has been taken, and the matter will probably go to the next congress, to be held in Russia three years hence.

Surface ice doubtless protects the water during the severest winter weather, but it must be remembered that it also shuts off the sun's rays which are copiously absorbed by the water. The increasing power of the sun in the late winter and spring is a powerful factor in elevating the water temperature; but an opaque coating of ice keeps the water cold and hence tends to preserve the ice sheet. It has been found that about 25 per cent. of the sun's heat actually penetrates the ice sheet. I have observed the ice sheet of Lake St. Peter, on the St. Lawrence, move out at least ten days earlier than usual by the expedient of opening a space in the river above the lake by means of an ice-breaker, and thus allowing the water flowing into the lake to accumulate the full power of the sun's rays.—Prof. H. T. Barnes, of McGill University.

EDITORIALS

Refrigeration and the Present Needs

Popular conception links the field of refrigeration with ice-making plants, cold-storage warehouses and breweries, and few except those having an intimate acquaintance with the subject realize the magnitude of the industry and the prospects for the future. It is generally known that the use of artificial ice is on the increase, but perhaps it is not realized that the manufactured product is gaining the ascendency over nature's store.

Figures given out by S. S. Van Der Vaart at the recent congress in Chicago, indicate that in New York City sixty-five per cent. of the ice consumed is artificial. When a number of plants now in progress of erection are completed, it is expected that the above percentage will reach three-quarters of the total output. When this proportion is compared to less than one-fifth nine years ago, the rapid growth will be evident. In cities near our northern boundary and even in Canada, where natural ice is plentiful and cheap, ice-making plants have been installed or are contemplated, and in time the use of a considerable amount of artificial ice may be expected.

In the United States it is estimated that there are thirty-five hundred ice-making plants, with a total annual output of eighteen to twenty million tons. The capital invested in the ice-making industry proper is not less than a hundred and fifty million dollars. In refrigeration, including cold-storage and all other cooling, fully fifty million more is invested in machinery. The possibilities here are enormous. Refrigeration is now applied to approximately a hundred and fifty industries, and every day sees some new application or extension to those existing. Refrigeration is now used in the laundry, in the mining and paper-making industries, in silk and woolen mills, in the preservation of seeds, in the manufacture of a great variety of products and even in the cure or prevention of tropical diseases.

Notwithstanding the technical and economic importance of refrigeration and the advanced development of the science in the leading countries of the world, education along this line has not received its proper share of attention. The rapid development of the past few years calls for a change. Men educated to design and efficiently operate the various systems employed are in demand. Due to some extent to the efforts of the International Association of Refrigeration notice of the conditions existing is being taken at educational centers. In some cases special courses have been provided, in others, elementary instruction and in many more full recognition is given to the importance of the field. The laws governing refrigeration and the intricacies of the science are in a class with those of steam engineering and are as difficult to master. Hence the need for thorough instruction and the installation of complete courses in all engineering schools.

Prompt action is needed if the number of men trained to the science is to meet the demand. The growth or extension of the refrigerating field has not reached the high-water mark. It is only beginning. The increase in the immediate future should be rapid, and the calls for men will be more and more numerous. In the past our great universities and technical schools have not hesitated to add to their instruction or establish new courses when the need became evident, and it is confidently expected that they will meet the present requirements in the refrigerating field.

Your Son's Vocation

The *American Lumberman* has made a suggestion that has been flatteringly indorsed by men prominent in its field. It is to have a "Junior Day" at their annual conventions to which the sons of the lumbermen will be invited. This is only part in a larger plan to make the business attractive to the sons so that they will follow in their father's footsteps if they appear to have a bent that way.

So much by way of submitting a similar thought to engineers. How to make engineering appeal to the growing boy. There is much to be said on both sides as to the desirability or nondesirability of having the young man follow his father's profession. On one point certainly all will be agreed. It is positively wrong to coerce the youth into any line of work that he is not in sympathy with or for which he has no natural fitness. When a boy has had sufficient opportunity to judge of his father's business or profession and decide whether or not he wishes to engage in it, then, by all means, he should be left absolutely to make his own decision. If an attempt is made to force him into an uncongenial line of activity he will start with a handicap that almost certainly will defeat his succeeding. Many obstinate fathers have made this mistake.

On the other hand, there are those who have been so anxious not to unduly influence their sons that they have gone to the other extreme. As a result the sons have felt their sires either had no interest in them or positively did not want them to follow their lead. Where a man has failed of success himself he may naturally discourage his son's taking up the same line of work. Having succeeded in his own chosen field, a father has no excuse for failing to acquaint his son with the work so that the boy can judge of his interest in it. Once convinced of a youth's desire to enter a certain field and the probability of his succeeding in it, it is pure neglect for a father to fail in opening opportunities for him.

Entirely apart from the question of good to the individual is the one of the best interest to the world at large and progress. Is it wise to keep a line of descent in one field of work, or, as the farmer has learned, is it preferable to have "rotation in crops," so that the soil may be most fruitfully used? Is there any analogy? Is the race benefited by not having the brains of any one family too long devoted to the same purpose? Will there

be a freshness of material for development along new lines every generation or so?

No doubt some will be reminded of the vocations in which skill pays a large part, and many generations have been carpenters, or weavers, or expert artists or artisans of one sort or another. Who can deny that heredity played a large part in the ultimate proficiency secured?

So much by way of opening up the subject for our readers' thought and consideration. We are not prepared to settle the problem for anyone. We do believe, however, that it will work itself out in almost any case where the father is not too busy or indifferent to take any interest in it. The boy should neither be slighted nor driven. Let him know his father's profession first, then if he prefers another he should not be prevented from embracing it.

Municipal Ownership

Against the municipal ownership and operation of a power plant to supply a city and its inhabitants with light and power, the favorite argument is "politics." And quite naturally, for when politics are allowed to interfere it is impossible to make a favorable showing in the plant. In a great many cities of this country business-like methods are not employed. Red-tape and political considerations form a serious handicap and even where criminal graft is not present, favoritism and influence have an effect which usually result in the city paying more for the land, the construction of the building and the entire power equipment than it would cost a private corporation. Even after the plant has been put into operation this same influence might increase the price of the fuel and supplies and so control the employment of the management and labor as to preclude efficient results.

The answer to such an argument is easy. Remove the plant from politics, see that competent men are appointed to run it, and an important point is to pay liberal salaries for services rendered. A good engineer in a large plant is worth his weight in gold. When a municipality recognizes the truth of the above assertions, and adopts them, there will be no chance for failure.

Under the above conditions the municipal plant has all the advantage. It can borrow money for construction and equipment at a lower rate than an individual, and then there are the dividends which, if there are any in a municipal plant, revert to the consumers of current and insure a rate lower than could be given with profit by a private corporation. In the plant the boilers, engines and generators do not care who owns them. Put them into the hands of men equally competent, who are given a free swing and are held responsible for results, and they will produce current as cheaply for the people as for a corporation.

As expressed in these columns some years ago, the results will speak for themselves. The business of producing electricity is becoming systematized. The cost of the plant per kilowatt, the cost of generating current and the cost of distribution are becoming well known and any deviation one way or the other can be easily detected. The consumer would know by the price he is paying for light or power.

A notable example of a municipal plant operated on the above lines is the one at Pasadena, Calif. According to the sixth annual report which is abstracted on other pages of this issue, the plant has been remarkably successful. Great credit is due the management and indirectly the city, whose broad policy has made efficient conditions possible. Based on the old rates charged by its present competitor the municipal plant has saved sufficient to pay for itself in five years. On sliding rates of five to three cents for lighting and four to one- and two-tenths cents for power the plant has made a profit of 8.18 per cent. Before the inauguration of the municipal plant a base rate of twelve and one-half cents was charged for the first 666 kilowatt-hours. The enormous difference is evident and not only Pasadena, but also the surrounding cities were benefited.

Such instances as these tend to restore confidence in public ownership and show that a municipal plant run on a business basis is not only practical, but will pay large returns on the investment.

Causes of Steam-Plant Troubles

One reason why some purchasers of power-plant machinery are always in trouble is that they assume that they know more about the operation of the machine than do the manufacturers. Because of this assumption, impossible operating conditions are imposed upon the machine and economical results are then expected.

Often operating conditions are aggravated by the use of second-hand pumps, engines and boilers. A defective pump can be an element of danger by failing to deliver the necessary amount of water to the boilers. For instance, in one plant a single-cylinder power pump was used as a boiler feeder. Although the lift was not great the pump frequently failed to pick up after being stopped. On one occasion the engineer did not notice that the pump was not pumping water until just before the water went out of sight in the water glass of the boiler. A greater delay in discovering the fact would have ended in trouble.

A defective engine may be an instrument of danger because of the absence of a decent safety stop or having none at all. There are hundreds of patched engine frames in use that are more fit for the scrap pile than for withstanding the strains produced by the power strokes of the piston. The owners take a chance that the engine will hold together a few days, weeks or months longer.

Most dangerous, however, is the second-hand boiler, the boiler that has been in operation for years and subjected to ignorant abuse, or the boiler that is carrying a higher steam pressure than safety warrants. In case of accident there is no excuse for the owner of such apparatus to hide behind.

If machinery is operated in defiance of the advice of men who know their business, the blame for resulting troubles must rest on the unwise owner.

Advice freely given is seldom heeded. If paid for it is taken at a greater value, but it is useless to pay for advice if it is not to be followed in putting in the work contemplated, or in operating the equipment after it has been installed.

Just because there are CO_2 recorders, steam-flow meters and draft gages in the boiler room, don't think the fireman is a combustion engineer. His pay envelope tells him that the firm does not think he is.

READERS WITH SOMETHING TO SAY

Wants to Clean Producer Gas

We plan to install instruments for measuring the heat value of the gases from our gas producers. These gases are not cleaned or scrubbed, but are used in the raw state and therefore contain a high percentage of tar, which must be taken out before the gases enter the instrument.

Perhaps some of the readers who have had experience with gas producers will be kind enough to answer through these columns how we can satisfactorily filter or scrub the gas. We have 16 producers and the pipe lines to the instruments will be direct from each producer to the instrument.

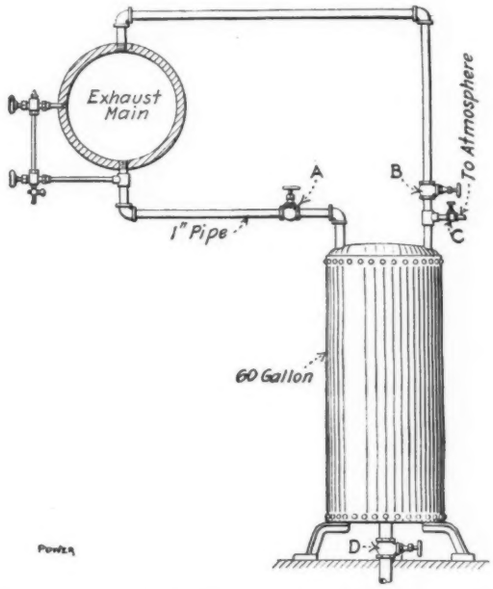
Will a coke filter be of any use or would it be advisable to clean the gases by water alone?

F. D. HARGER.

New York City.

Condensate Accumulator for Exhaust Line

We have a 750-kw. two-stage, vertical turbine which exhausts into a barometric condenser. From the outlet in the base of the turbine to the vertical exhaust riser of the condenser is about 15 ft. In this horizontal pipe



CONNECTIONS FOR CONDENSATE RECEIVER TANK

much condensed water would accumulate which was both troublesome and dangerous, as the exhaust base of the turbine might be flooded. The use of a trap for removing this water was suggested, but the following plan, which was simple and inexpensive, was adopted and gave complete satisfaction.

The exhaust line was tapped and threaded near the condenser for 1-in. pipe, one hole being tapped in the top and the other in the bottom, as shown. From these two holes, two 1-in. pipes, led into a 60-gal. tank, placed on the floor. These two lines were fitted with valves and a tee was fitted with a pipe and valve opening to the atmosphere. In the bottom of the tank, a 1½-in. pipe fitted with a valve was connected for draining the tank.

In addition a gage-glass was connected, the bottom to the pipe at the lower outlet, and the top at one-half the diameter of the pipe from the bottom. As soon as water shows in the gage-glass, the attendant closes the valves *A* and *B*, and opens the valves *C* and *D*. This allows the tank to be rapidly drained. After draining the water, valves at *C* and *D* are closed and *A* and *B* opened, which again connects the tank to the exhaust line.

JAMES M. PURCELL.

Richmond, Va.

Getting Clear Water from a Muddy River

The following problem is a very practical one because one similar may be "put up" to some reader at any time, and to solve it is not a very easy matter, until one knows how. In fact, I have known many engineers to doubt the possibility until they were given the facts.

The principles used in the solution described can be applied to similar problems by bringing about the same conditions, which existed naturally in this case, through artificial agencies, if necessary.

The problem in its original state was as follows: A brewery had been built on the high bank of a large river which was always muddy, and the building was about 50 ft. back of the river's edge, owing to the steep slope of the bank, as shown. It was not intended to use this river for supplying the water as another source appeared available, until the owners found out that the water they had anticipated using would not be supplied them. Under such conditions they called in a consulting engineer and told him to get them a suitable supply of water, without requiring a considerable outlay, no filtering apparatus was desirable if it could be avoided, but the water had to be clean and in large quantities.

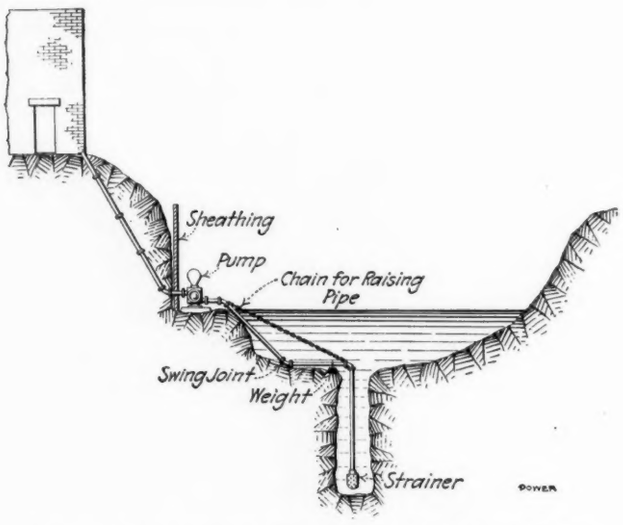
It was interesting to get a solution of this problem from the data as it was thus submitted. It may be added that the colder the supply of water obtained was, the greater would be the economy of the plant.

The consulting engineer decided that the river was the most feasible source of supply to look at first, but it was so muddy with a clayey kind of soil that he was very nearly discouraged at the outset. However, hiring a boat he took a trip across the river and made a series of soundings, and in one place about 50 ft. from the bank on which the brewery was, he discovered a hole about 40 ft. deep in the rived bed, the general depth of the river was 50 ft., so that the distance from the surface of the river to the bottom of the hole was about 90 ft. The next day the engineer made a special arrange-

ment of bottle so that he could get a sample of the water in the hole, and immediately proceeded to locate the hole and get the water. On getting the sample to the boat he found it was clear and on testing its temperature found it approximately 50 deg. F. This temperature was afterward found to be practically unvariable throughout the year. On testing the river water he found it was muddy all above the hole and had a steady, slow current.

Having found a source of clear water the problem was how to get it to the brewery without having it contaminated with the muddy water. This part of the problem was solved by anticipating that the hydrostatic pressure of the river would force it up into a pipe extended with its open end into the hole and clear water.

The whole problem was then solved by running a pipe line from the brewery to a pump installed at the water's edge, and supplying the pump from the hole by means



PIPING ARRANGEMENT FOR GETTING CLEAN WATER FROM MUDDY STREAM

of a pipe line run from it to and into the hole in the river bed. To make the line in the river readily accessible for inspection and repairs it was installed with a swing joint that would permit the length of pipe to the hole to be raised by means of a chain permanently fastened to it, the pipe being raised and moved sideways to allow it to rise out of the hole. A weight was also put on the pipe to keep it in place when lowered into the river.

In using the water it was only necessary to run the pump a few minutes to clean out the muddy water which had got into the pipe on lowering it, and then raise the water from the river, a distance of about 10 ft., and then force it up the hill. The supply satisfied the owners and it is believed to be the main supply up to the present time.

The reason why the water at the bottom of the hole or rather near the bottom is clear, is, in the writer's opinion, because the water in the hole is still, this permits all solid matter in this water to settle (under the action of gravity). The muddiness or color of the water is caused by solid matter, that is, earth or clay in a very minute state. This solid matter cannot settle easily in a flowing river, unless it is of considerable length and passing through a rocky country, but remains suspended, keeping it muddy; but where the water becomes still enough, the solid matter will settle.

It is true that muddy water must be supplied to the hole in this case, as some is taken up by the pump, but such muddy water soon gives up its earthy matter and is "lost" in the great quantity of clear water already in the hole and does not appreciably affect the clearness of the supply. In fact, the flow of water in the hole being downward, due to the position of the inlet, will tend to assist gravity in settling the solid particles.

The presence of the hole is apparently due to a peculiar rock formation in the bed of the river. It would seem that this condition might be duplicated by driving a tank into a river bed where such a natural condition did not exist; the top of the tank would not necessarily have to be below the river bed.

The reason why the water in the hole was of a uniformly low temperature during the whole year, was apparently due to the tendency of the cold water (being denser) to keep to the bottom strata of the river during the summer, and in winter the warmer water would be at bottom of the river while the freezing water and ice were on top, and this would make the temperature at the bottom of the hole about 48 deg. F. in winter and in summer the temperature would not be much higher for the reasons already stated.

A. P. CONNOR.

Washington, D. C.

Position of Jam Nuts

The learned discussions of the proper location of jam or locknuts take me back to the time when I was a cub in the shop. Theoretically the thin nut should probably be underneath. Practically it is a nuisance to put it there, owing to the necessity of using a thin wrench.

But why all the fuss over it anyhow? The check nut alone is stronger than the bolt if it is a halfway decent fit as can be proved by pulling a bolt in two with the nut. So it is entirely unnecessary to waste time discussing whether to put it inside or outside, for either place is good enough.

But why use locknuts anyhow? The automobile builders have abandoned them for the castle nut and the locomotive builders are following suit. A few thin washers of varying thickness will take up anything needed, even on large bolts and the cotter pins make a positive lock.

JOHN R. GODFREY.

New York.

Soda Ash for Boiler Waters

The article by Charles H. Bromley, on the above subject, in the Sept. 16 issue, brings up several points that deserve further explanation. Soda ash is very widely used as a preventive of corrosion in boilers, and the common practice does not generally conform with the ideas contained in that article. At the outset attention should be called to the author's own correction of the amount of soda ash that needs to be present in the water to give a "safe" concentration; that is, a concentration at which corrosion is prevented. In place of 55 grams per liter the author intended to state 1.59 grams per liter as the minimum amount of soda ash necessary to prevent corrosion, which correction appears in Mr. Bromley's note

in the Sept. 30 issue of POWER. This concentration is still higher than it is necessary to carry in the boiler to prevent corrosion, as is daily demonstrated by users of soda ash in the boiler-feed water, the reasons for which are:

1. Under boiler pressure some of the soda ash is converted to caustic soda. This reduces the concentration of soda ash necessary to prevent corrosion, as was demonstrated by Heyn and Bauer and Cribb and Arnaud.

2. The inside of the boilers is dark, and light very materially hastens corrosion, as Cribb and Arnaud, and Friend have demonstrated. The experimenters that have investigated the corrosion of iron in a solution of soda ash have conducted their experiments in glass beakers exposed to the light.

3. Where soda ash is added to the boiler water a slight protective coating of calcium carbonate is deposited on the boiler tubes and plate. If the water has been properly treated by soda ash before entering the boiler, this coating will be soft and the tubes will have the appearance of being whitewashed.

For the above reasons experience has demonstrated that a concentration of soda ash high enough to prevent corrosion may easily be carried in the boiler. Sea water and some natural waters contain magnesium chloride. The magnesium chloride breaks up under boiler pressure, forming magnesium oxide and hydrochloric acid. Such waters must contain a higher concentration of soda ash to neutralize this hydrochloric acid.

The above mentioned article referred to the corrosion of the steam main that sometimes takes place where soda ash is used to prevent corrosion in the boiler and gave as its cause the "unsafe" concentration of soda ash that is deposited on the main when the boiler primes. Probably the greater cause for this is the corroding oxygen that is driven off from the boiling water in the boiler. The corrosion in the boiler was prevented by the soda ash, but the lack of it in the steam main caused the oxygen and steam to be very corrosive. Where corrosion of the boilers is due to the oxygen, the boiler-feed water should be heated by an open feed-water heater before going to the boiler, rather than to depend upon any chemical reagent to prevent corrosion. Experience has shown that where no oxygen is present, pure water is not capable of causing corrosion.

JOSEPH D. VODER.

Philadelphia, Penn.

The Factory Fire Chief

Mr. Koon, in the Sept. 23 issue, in regard to the requirements of the factory fire chief, states that the use of automatic sprinklers would make the fire chief wholly unnecessary, and that there would be no serious losses from fire, etc. The sprinkling system is a great thing, but like everything else mechanical, it frequently fails to work as it is supposed to, and the more modern the fire system is the more apt it is to be complicated. And every engineer knows that complicated mechanism of any kind requires very close attention to keep it in proper working order; hence the necessity of a fire chief.

Whether or not this office should be filled by the engineer depends on many circumstances. From the viewpoint of an engineer it seems out of place to require him to assume the additional duties of fire chief as he already has enough to do for the wages he gets. In looking at it from the company's standpoint the chief engineer is the most logical employee to be chosen as fire chief. He more thoroughly understands the equipment, such as pumps, hose, extinguishers, piping, etc., and the care of them, because it is part of his business as engineer to know these things, and part of his equipment of pumps and help would be called into play in case of fire.

The extra work added to the oftentimes overworked engineer might make it necessary to put an additional man on the force under the engineer. The average chief engineer could also assume the duties of fire chief without any trouble. I believe that the greater part of the engineers would be willing to assume the additional responsibility provided the pay is increased in proportion. The objections of the employer to increasing the pay is usually the cause of the trouble in such cases.

J. C. HAWKINS.

Hyattsville, Md.

Graphite Remained in Economizer

E. C. Sutton's letter in the Aug. 19 issue, concerning the failure of graphite to prevent scale forming in his boilers, was read with interest.

Mr. Sutton may have improperly fed the graphite, for if the graphite was properly distributed in the boiler the scale would not be white.

I have been using graphite for boilers for some time and I am satisfied with results. At first I was disappointed with the results in one plant and was about to notify the makers of the graphite, when it occurred to me that it was very queer that if I was feeding graphite there should be no trace of it in the boiler. Accordingly, I examined the economizer, and found that all the graphite had remained there, owing to the very sluggish circulation of the feed water. So, after feeding graphite between the economizer and the boilers, good results were obtained. Perhaps Mr. Sutton is feeding through the blowoff pipe, in which case all the graphite will be found in the mud drum.

E. R. PEARCE.

Rochdale, Eng.

Orsat vs. CO_2 Recorder

Recent discussion in the columns of POWER as to the relative merits of the CO_2 recorder and Orsat have brought forth various expressions of opinion as to the faults and failings of the two devices. Since both the recorder and the Orsat have a proper field of usefulness in the modern boiler room, I have no desire to take either side in the controversy but wish to comment on a letter by Walter C. Edge in the issue of Sept. 16, 1913.

Mr. Edge states in his second paragraph that "an engineer after a number of tests can tell whether any serious amount of CO is contained in the sample by the percentage of CO_2, provided that the furnace is normal and is worked under normal conditions. One can keep 14 per cent. or less CO_2 and be safe as far as CO is concerned."

Unfortunately, no detailed instructions are given for ascertaining the presence of "any serious amount of CO" from the CO_2 indication. Furthermore, "normal" fur-

nace conditions which are mentioned as a prerequisite to this determination are not defined.

The last statement quoted to the effect that 14 per cent. CO_2 indicates a safe working condition I must take exception to. In the absence of any definite knowledge of the amount of CO, 14 per cent. CO_2 is undoubtedly a reasonable figure to use, but an Orsat may reveal the fact that 15 per cent. in some given case is the proper standard to work to. This, if attained, would mean a considerable saving in fuel over the results if Mr. Edge's rule is followed. In other cases it would not be safe to work to as much as 14 per cent. as a standard.

It would be a simple matter for anyone who has done much work with the Orsat to submit in detail analyses of flue gases which show results entirely disproving the general statement made by Mr. Edge. From my own experience I should only feel justified in saying that, in the average case with fairly good boiler operation, CO in greater or less amounts is apt to be present when the percentage of CO_2 exceeds 14 per cent., but as CO is in no sense proportional to CO_2 it is frequently present in large amounts with CO_2 much under the 14 per cent. specified.

H. S. Vassar.

Newark, N. J.

Value of Engineers' Services

In the issue for Aug. 19, page 272, is an editorial that is full of "meat," entitled, "One-Sided Development." I have read this, re-read it and then read it again.

It occurs to me that you have broached a phase of the situation that may be deeper than you thought when you wrote the editorial. It would seem to have its answer in the fundamental conception as to what constitutes an engineer. If an engineer be merely an engine runner, the first page of your Sept. 9 issue would seem to settle the matter by classing him as a "greaser" and of small value. If an engineer is more than a mere engine runner, what is he?

You say, "No wonder he is underpaid, which means simply that he has not, as a rule, acquired the business ability needed to sell his own services at a price which represents his real value." Now, does not this very one-sided development referred to, which prevents him from accurately estimating his value to his employer, also seriously depreciate the very value he is seeking to estimate the amount of? If his development is so one-sided that he has no accurate measure of its value, isn't it also so one-sided that he cannot accurately estimate other values in the plant under his control?

This raises another rather pertinent question, viz., What is an engineer for? If he is only to run the engine and keep it in good repair he is merely an engine runner and it would seem should not be termed an engineer at all. As such he does not earn a great deal because this is work that is relatively simple. If, on the other hand, he is a business economist in charge of the power plant, with sufficient skill to know when his plant equipment is functioning properly and at the greatest efficiency which it is capable of delivering and of keeping it in this condition without undue expense for repairs, then he will, I believe, be able to accurately estimate the value of his services to the concern employing him and will be able to show them what he is earning in such terms that he will receive it.

I do not attempt to answer your question, but wish to ask some further ones: Does not the lack of commercial instinct which prevents an engineer from marketing his services to good advantage also seriously impair his value as an engineer? Or, if he have not this faculty, or training, for estimating relative values, is he an engineer at all? Isn't he merely an engine runner or perhaps a greaser, and as such, would it not stand him in better. And again, do you not believe that frequently, when he has gained this ability to accurately estimate values (that of his own services included) he will be greatly surprised and chagrined to find that his services really had such small value?

R. L. Ellis.

Philadelphia, Penn.

Fastening Loose Babbitt

In regard to the method used by Mr. Kopple to fasten loose babbitt in a bearing shell, I do not approve of the method of using screws as he shows. These countersunk screws are made of hard metal and have a very sharp edge. They may be set well below the surface of the babbitt but are liable to work out, break off, or the babbitt may become worn down in time so that the shaft will bear on the heads of these screws, and the shaft will be scored by them.

The proper way to cure a loose babbitt lining is by re-babbitting the shells, but as this requires considerable time and is expensive, the old babbitt may be fastened and used a long time before re-babbitting is necessary. I have done this by drilling and tapping the holes as Mr. Kopple did, but instead of using steel screws I used either copper or brass rods threaded, and screwed in tight, then cut off and riveted down into the countersunk hole in the babbitt. These will remain tight, especially when the bearing warms up, and, when the babbitt wears down until they strike the shaft they will not score it as they are softer than the shaft and will wear away first.

J. C. Hawkins

Hyattsville, Md.

Abandoning Boiler in Case of Fire

Fred W. Hener, in the issue of Sept. 16, asks a question that will doubtless draw forth many ideas of what is best to do.

Here is what I advise: Close the ashpit doors, open wide the furnace doors, open the back-connection doors, close the damper, put on the injector, close the main and auxiliary stop valves, and "beat it while the going is good."

There could be no explosion of furnace gases, the pop valve would take care of the steam, and the injector would soon "fill her up three gages and a smokestack," and hold the steam down, the fires meanwhile having no draft, would not furnish more steam than the pop valve could relieve, and the engineer could do no more for his boiler and should save his life before the building collapses.

R. O. Wilkie.

Miami, Fla.

INQUIRIES OF GENERAL INTEREST

Flywheel Function—What is the office of a flywheel?

J. E. S.

To store up the energy of the piston in those parts of the stroke where the energy developed is in excess of the average, and to restore it to those parts of the stroke where it is less than the average, thereby carrying the engine over its dead centers and making a near approach to a uniform rate of rotation of the crankshaft.

Piston Displacement—How is the displacement of an engine determined?

J. E. S.

The displacement of an engine is the volume swept through by the piston, consisting per stroke, of the number of cubic inches of volume obtained by multiplying the area of the piston in square inches by the stroke in inches.

Displacement in cubic feet would be the displacement in cubic inches divided by 1728. Displacement per minute would be the displacement per stroke multiplied by the number of strokes per minute.

Effect of Caustic Soda on Lubricating Oil—We filter and use again the lubricating oil from an oil engine in which caustic soda has been fed through the lubricators to prevent gum and carbon accumulating on the pistons and rings. What will be the effect of the caustic soda on the lubricating oil and the bearings?

E. C. S.

The caustic soda would not injure the bearings directly, i.e., by any chemical action, but by cutting the oil would reduce its lubricating quality, preventing the pores of the bearing surfaces from being filled and glazed over, thereby causing more friction and more rapid wearing away of the bearing surfaces.

Pump Horsepower—How is the horsepower of pump required to deliver a given quantity of water against a given head determined?

K. W. A.

The weight of water pumped per minute multiplied by the head gives the foot-pounds of work done in one minute and this divided by 33,000 gives the net horsepower. The latter divided by the efficiency of the pump will give the power required to be put into the pump by the motor, waterwheel or whatever source of power drives it. Usually, for a direct-acting steam pump, the efficiency includes that of the steam end so that the net horsepower divided by the efficiency gives the indicated horsepower required.

Over-Stroke—What is "over-stroke," what causes it and how is it remedied?

C. W. B.

The term "over-stroke" is most commonly applied to a too long stroke of a pump piston. An engine piston may make an over-stroke from the lost motion of the crankpin and the crosshead pin or their brasses, to remedy which the bearings should be taken up and the length of the piston rod properly adjusted. The over-stroke of a pump is the reverse of "short-stroke" and is to be remedied by adjusting the valve motion, the method depending on the style of pump. In a duplex steam pump with slide valves the pump is to be reversed earlier in the stroke, either by moving the "spool" on the piston rod, which will lengthen the stroke toward one end and shorten it toward the other, or by adjusting the tappet nut on the valve rod to open the valve earlier in the stroke.

Ammonia Condensers—Is not the atmospheric ammonia condenser in which the ammonia gas enters at the top and the liquid leaves at the bottom the most inefficient in use today?

R. H. R.

It is hardly fair to call the open-air condensers with top-gas inlet the most inefficient type, for they give better results than most of the submerged condensers usually used. The disadvantage of these condensers is that to take out the sensible heat of the ammonia vapor, the coldest condensing water is used, and liquefaction takes place at a point where the water already has been heated several degrees. A further disadvantage of these condensers is that the liquid ammonia leaves where the condensing water flows from the apparatus, so that the final result is a higher condensing pressure and a higher final liquid temperature than is obtained in purely counter-current condensers.

Increasing Engine Speed—What change can be made to a fly-ball governor to increase the engine speed from 95 to 115 r.p.m. where there is no room to add more weights to the governor?

E. H.

An increase of speed from 95 to 115 r.p.m. would be 25 per cent. Before making such an increase, the builders of the engine should be consulted to learn if it is safe. An engine can be speeded up by making the governor run slower by increasing the size of the pulley on the governor or by reducing the size of the governor driving pulley on the main shaft. It is usual to build up the pulley with a lagging of leather, but for the increase of speed here contemplated the ordinary double-flange pulley on the governor would undoubtedly have to be replaced by a new pulley of larger diameter, as the lagging required on the old pulley to make it sufficient in diameter would not leave the necessary depth of flanges.

Boyle's Law—With reference to compressed air what is the meaning of $pv = 26{,}200$ ft.-lb. for 1 lb. of air as per Boyle's law?

J. M.

According to Boyle's or Mariotte's law, the volume of a gas diminishes in the same ratio that the pressure upon it is increased, if the temperature is unchanged. This law is found very nearly true for air and other gases. If p = pressure at a volume v and p_1 = pressure at a volume v_1 then $p_1v_1 = pv$; so that pv = a constant. p = intensity of pressure (absolute), and for air computations is usually in pounds per square foot, while gage pressures are given in pounds per square inch, so that p = (gage pressure + atmospheric pressure in pounds per square inch) $\times$ 144. v = volume, is usually assumed in cubic feet.

One pound of air at 32 deg. F. and under a barometric pressure of 29.92 in. of mercury (= 14.6963 lb. per sq.in. abs., or 2116.3 lb. per sq.ft.) has a volume of 12.387 cu.ft. So that for a pound of air its absolute pressure in pounds per square foot $\times$ its volume in cubic feet (or pv) = $2116.3 \times 12.387 = 26{,}214.6$ and the value 26,214 is usually taken rather than 26,200.

The product of $p \times v$ will always equal 26,214 ft.-lb. per pound of air at 32 deg. F. no matter what value may be assumed for p or for v.

Condensing Water for Ice Plant—For a can system compression ice-making plant with an atmospheric ammonia condenser, how many gallons per minute of 66-deg. condensing water will be required when making 100 tons of ice per 24 hr.? What would be the probable final temperature of the water?

R. H. R.

The quantity of water is difficult to estimate without knowing the exact local conditions under which the plant has to operate. For minimum steam consumption, which is really more important, as it directly affects the fuel consumption of the plant, it has been found that, for a simple Corliss engine operating a refrigerating machine, and a standard, duplex, direct-acting steam pump furnishing the water for the plant, the minimum steam consumption will be secured when about 1.7 gal. of water is showered on the condensers per minute per ton of actual refrigeration. Figuring, therefore, that 100×1.5 tons actual refrigeration will have to be done to manufacture 100 tons of ice, a total of 255 gal. of 60-deg. water per min. will be required. Under ordinary conditions of operation, there will be rejected, from the ammonia condensers 250 B.t.u. per min. per ton of refrigeration, which on a basis of 1.7 gal. of water per min. would represent a rise of about 17.6 deg. F., so that the final temperature of the condensing water, disregarding heat absorption by the atmosphere, would be 83.6 deg.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—II

Calcium Sulphate

The chemical formula for calcium sulphate is $CaSO_4$. All the elements in this compound are familiar to the readers of this department so it is only the compound itself that need be studied. One of the common substances composed of calcium sulphate is plaster of paris. Unlike the carbonates, calcium sulphate does not require CO_2 to assist it to dissolve. Pure water will take just as much as water heavily charged with CO_2. A fact that is very important to the engineer is that calcium sulphate is more soluble in cool water than in hot. According to some authorities the temperature at which the most calcium sulphate can be dissolved in a given quantity of water is about 90 deg. F. As the temperature increases the solubility of this compound gradually decreases until at 302 deg. it is practically insoluble. Because of this characteristic and the fact that the scale it forms is very hard and has great cementing powers over other substances, calcium sulphate is a troublesome and dangerous impurity. Usually it can be fought only with suitable chemical compounds.

Magnesium Sulphate

The fourth and last impurity we are going to consider is magnesium sulphate, although as was stated last week there are several others that are sometimes encountered. The chemical formula for this compound is $MgSO_4$ which, as the name indicates, is the same as that for calcium sulphate except that magnesium takes the place of the calcium. And, like the other sulphate, it dissolves more easily in cool water than in hot. At 302 deg. it precipitates or deposits as a monohydrated salt, the formula being $MgSO_4H_2O$. It will be noted that the elements composing water (H_2O) have been added. This fact is indicated in the name by the word monohydrated, mono meaning one and hydrated meaning watered. As used, the word means that one molecule of water has been added to or joined with each molecule of magnesium sulphate.

By itself magnesium sulphate does not really form a scale but its presence in feed water is undesirable because it interferes with the treatment of the impurities that do form scale.

Methods of Treatment

Water containing impurities detrimental to good boiler operation can be treated in several ways, the method to be employed depending on the nature of the impurities contained. For removing mud and sediment the water may be filtered or it may be allowed to stand and "settle" before it is fed into the boiler. For what is called temporary hardness the water may be heated to 180 deg. or more. Temporary hardness is defined as hardness which can be eliminated by heating to or nearly to the boiling point (212 deg.), and is caused by the carbonates which, it will be remembered, are precipitated by heat. Hardness can be detected and its degree estimated by the effect it has upon soap.

For permanent hardness more intense heat (to at least 302 deg.) may be applied as on a closed heater or chemicals may be employed. It is the sulphates that cause permanent hardness because mere boiling at atmospheric pressure does not eliminate them.

These two terms, temporary hardness and permanent hardness, are old names invented long ago when chemistry was not as well understood as it is today. People found that water from certain sources made soap curdle instead of producing a lather. Such water they called hard. Next, they discovered that boiling sometimes improved the water; consequently such water was said to have temporary hardness. Sometimes, however, the water was only slightly or not at all improved and such water was said to have permanent hardness.

Feed water may be treated with chemicals either outside or within the boiler, the former being preferable, because the impurities are eliminated before the water is fed to the boiler and so blowing down and cleaning are required less frequently. When treatment is administered before the water is fed it is advisable to provide chemicals for the elimination of both the carbonates and sulphates, if both are present. But when treatment is administered after the water is fed only a chemical for the sulphates is required, because the heat takes care of the carbonates.

Treatment for Carbonates

Calcium carbonate can be precipitated before the water is fed to the boiler by adding to it the proper quantity of lime, slaked lime or caustic soda.

The chemical formula for lime is CaO and that for slaked lime is CaO_2H_2, and when either of these is put into water containing calcium carbonate (in the form of calcium bicarbonate, due to the presence of CO_2) a chemical reaction takes place in which the calcium of the lime joins the calcium, carbon and oxygen of the bicarbonate, producing two parts of calcium carbonate and the hydrogen of the bicarbonate joins the oxygen and hydrogen of the slacked lime producing two parts of water. The equation is

$$CaH_2(CO_3)_2 + CaO_2H_2 = 2\,CaCO_3 + 2\,H_2O$$

The calcium carbonate, being insoluble, drops out or is precipitated.

The chemical formula for caustic soda, whose chemical name is sodium hydrate, is NaOH. If this is put into the water instead of the lime, part of the carbon and oxygen of the calcium bicarbonate combines with it to form sodium carbonate (Na_2CO_3) which is easily soluble in water. The calcium bicarbonate being robbed of part of its carbon and oxygen changes back to calcium carbonate and, being insoluble, it precipitates as before.

The treatment for magnesium carbonate is exactly the same as for the calcium carbonate.

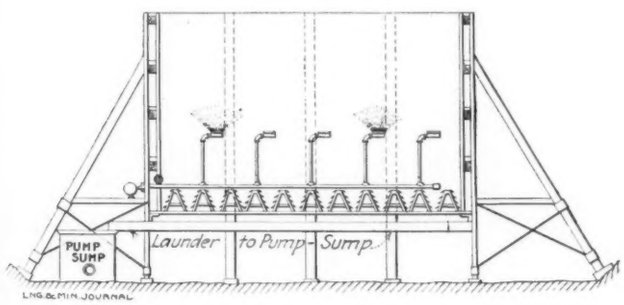
Treatment of Sulphates

Calcium sulphate ($CaSO_4$) can be precipitated by means of sodium carbonate, or soda ash as it is called commercially. The chemical formula for the latter is Na_2CO_3. When this compound is put into water containing calcium sulphate the sulphur and one-quarter of the oxygen in the calcium sulphate change places with the carbon in the sodium carbonate, producing sodium sulphate and calcium carbonate. The first of these is soluble and harmless and the second, being insoluble, precipitates as before.

The treatment for magnesium sulphate is exactly the same as for calcium sulphate.

Spray Cooling Tower

The accompanying drawing shows the cross-section of a cooling tower in use at the South Mine, Broken Hill, Australia. It is designed on rather novel lines, the water to be cooled being admitted in the form of a spray, as shown, so that most of the contact between water and cooling air occurs while the water is suspended in a finely divided state, instead of while it trickles over inclined surfaces and drops from their edges, as in the ordinary



Section of Cooling Tower Using Spray System

type of cooling tower. The tower has inclosed sides and admits the cooling air through the bottom. The bottom itself consists of a series of launders into which the water is conducted by louvered frames. By means of transverse launders, the cooled water is conducted to the boiler sump.

Excellent results have been obtained from this type of cooling tower, attributable to the following conditions: (1) The air has a large and unrestricted inlet to the tower through the bottom only; (2) the sprayed water meets an equal supply of air in all parts of the tower; (3) the air and the vapor outlet is not contracted at the top and, therefore, there is a minimum restriction to the passage of the air, (4) the air is not retarded in its upward passage by the apparatus which is used to distribute the water.

As illustrated, the tower draws in the air by natural draft, but if desired it may be built lower and the draft furnished by wind shields disposed about the lower portion below the launders and louvers.—*The Engineering & Mining Journal.*

A Steel Chimney to increase the height of an existing brick chimney has been put in place on the Borland Building, Chicago. The steel extension is about 100 ft. high and 9 ft. diameter. It was raised in one piece to the top of the building and set in place on the brick chimney by a derrick having a spliced beam about 140 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Hey, feller, as an engineer, let us ask you what in thunderation becomes of your hard-earned money? Here's a highforehead declaring that "we are wasting six hundred million dollars yearly." Now you just buck up, and don't let folks know your business.

"Safety first" is the Pennsylvania Railroad's slogan. As this road employs 210,000 men and carries 150,000,000 passengers yearly, it's in a fair way to test out such a slogan. Other roads please copy.

Here's another instance where we can't get what we're worth. Your per capita wealth as an American is just $1360. A few simps, on learning this, went to Washington to get theirs. And they got it—not.

A bit of optimism from the "Coal Trade Bulletin": "If it isn't cars, it's labor. If it isn't labor, it's floods. If it isn't floods, it's drought. Any way you look at it, the coal man is bound to catch hades. Lately it has been all four. And yet he manages to wear a smile."

Electric vehicles have driven many of the old Dobbins into the discard. And now Turk and Golden, those patient old farm standbys, will soon have their usefulness limited to material for oxtail soup. Gasoline engines are doing it. At that, neither gasoline nor electricity makes good soup.

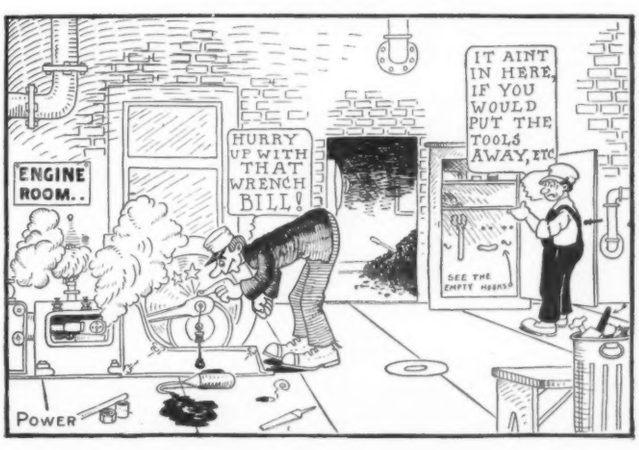
The banana, contends the Hon. John Barrett, has brought peace, prosperity and health to the Central American republic. Most everything has its good side, but personally, having slipped on a few, we are at odds with the outside of the banana.

A fourteen-page discussion by Arthur Williams and the Electric Vehicle Association of America appears in "The Central Station" for October. Having counted 2769 "I's," 9431 "my's" and 7645 "me's," we gave it up. We'll wait until T. R. returns from South America.

Most affecting was the "Electrical World's" heart sob over "the inspiring picture" drawn by Samuel Insull for the energy supply service which is now on display for those having "the general welfare of humanity at heart. It is the central-station man's ideal to furnish ALL the energy in a community". Sounds like one of those "ideals" that gobbles everything in sight—when that brand of idealist can get away with it.

"Terpezone" is the newest consumption cure. It's a "breathable gas," combining ozone and pinine, the essence of turpentine. So much "gas" has heretofore been expended on corraling the gullible, we hope this cure is going to stick.

"A Story without Words"



Boiler Attachments—III

By J. E. Terman

SYNOPSIS—A treatment of how and how not to connect the feed-water pipe to a boiler. The advantages and disadvantages of the automatic feed-water regulator and high-and-low water alarm are also discussed.

It is not such an important matter as to where a feed pipe enters a boiler, as it is where the feed water is discharged. On account of the accessibility for making connections, the horizontal-return tubular type of boiler is usually arranged to receive the feed pipe through the front head immediately above the tubes, or through the top of the shell. Most boilers of this type are equipped with some form of internal feed pipe, which acts as a heating device, tending to bring the water up to the temperature of that in the boiler, before it is brought in contact with any part of the boiler.

To make a suitable connection at the entrance point, a steel or composition bushing should be used, which is threaded externally to screw into the hole tapped in the boiler head or in the pad placed on top of the shell. This bushing should also be threaded internally at both ends, to connect the inside and external portions of the feed pipe. To avoid the expense of this bushing, it is sometimes customary to place a running thread of sufficient length on the end of the external portion of the pipe, so that it may be screwed through the head far enough to allow of attaching the inner portion of the pipe to its end. This arrangement is not satisfactory, and the use of a bushing should be insisted upon for all boilers equipped with an internal feed pipe. A common arrangement for the internal portion of the pipe for a horizontal, return-tubular boiler, is shown in the plan view, Fig. 15, where the pipe runs the entire length of the boiler and crosses over and is discharged between the tubes and the shell, near the rear head on the opposite side.

It is necessary that the internal portion of the feed pipe be hung securely from the shell or braces, and not allowed to touch the tubes or shell. Unless this precaution is taken, it is likely that a hole will be produced in the boiler at any point on which the pipe may rest, because, the pulsations of the feed pump cause it to constantly vibrate, which keeps the metal surfaces clean at the point of contact. Under these conditions, corrosive action of the feed water, which under ordinary conditions could not be noted, will destroy the metal with extreme rapidity. The speed with which corrosion acts under these conditions can only be appreciated after an experience or two.

One of the best feed arrangements for horizontal, return-tubular boilers is a steam-space feed, as illustrated in Fig. 16. This feed, if properly arranged, discharges the water through the steam space in a finely divided state, and it is heated practically to boiler temperature before it can come in contact with any of the metal parts of the boiler. This sudden heating, while the water is not in contact with any surface, tends to bring down a considerable portion of the scale forming matter in a granular form that can be readily washed out of the boiler. When discharging the feed water in the steam space of the boiler, to avoid a water-hammer, the pipes must be kept constantly filled with water. If the feed pipe comes from above, as illustrated in Fig. 16, a substantial trap or pocket must be formed below the outlet.

The general instructions in regard to feeding a boiler are that the feed pipe should be located so that the water will be discharged at the coldest point. This rule is often in error, and the writer believes could be replaced with, "locate the discharge so that the incoming feed water must mingle thoroughly with the water in the boiler, before it comes in contact with any part of the boiler that is likely to be injured by sudden temperature changes."

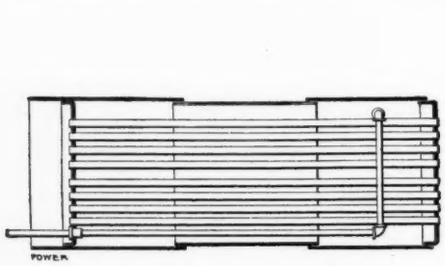


Fig. 15. Internal Feed Pipe

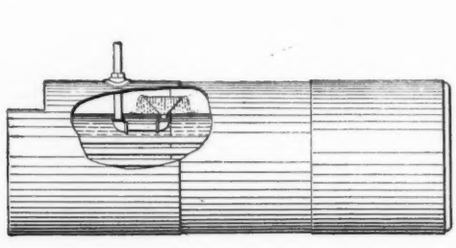


Fig. 16. Steam-Space Feed

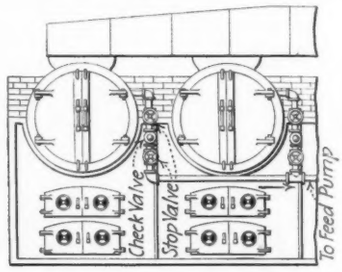


Fig. 17. Feed-Pipe Valves for Two Boilers

Two Ways of Introducing Feed Water

A method of feeding horizontal, return-tubular boilers that is fairly common, but which should never be used, is to attach the feed to the blowoff connection. This point of attachment is probably chosen, because it reduces the number of connections to the boiler by one, and also, because it saves some pipe and fittings. This method of feeding is severe on the boiler shell and is likely to produce cracks or leaking at the girth seams along the bottom of the shell, unless the boiler is of the very best construction.

The small vertical tubular boiler is best fed through the shell about one-half the tube length above the crown sheet. For large boilers of this type, it is best to use an internal feed pipe and discharge the feed water near the center of the nest of tubes. Sometimes the internal pipe is slotted or perforated, so that the feed is discharged across the entire diameter of the boiler. It is common practice to feed small portable boilers of this type in the water leg at a point about even with the top of the bed of fuel; this should always be avoided, as

it produces severe strains in the furnace sheet opposite the feed inlet and it is likely to produce cracking of the sheet or leakage around the stay-bolts.

With the locomotive type of boiler used for stationary work, a good point to discharge the feed water would be near the top of the tubes and about three feet forward from the tube sheet, but it is rarely put in at this point, because the average boiler of this type can not be entered above the tubes. The usual method is to discharge the feed in the water leg below the shell. The objection to locating the feed at this point is the same as for the water leg of the vertical tubular type of boiler.

The best readily accessible point for the attachment of the feed pipe in the locomotive type of boiler is in the shell below the waterline and near the front head. The location of the feed pipes on water-tube boilers has generally been decided by competent designers, and they are usually placed in the most suitable location.

Feed Valves

The feed valve is the most frequently manipulated valve on a boiler, and for that reason it should be easily accessible. If the plant is of such size that the fireman's duty is to watch the water level in the boilers the feed valves should be located at the front of the setting and within easy reach of the floor. A common and convenient arrangement for the feed pipes of horizontal, return-tubular boilers, set in a battery, is illustrated in Fig. 17.

It is best to use two stop valves on a feed line and locate the check valve between them. Then it is possible to remove any obstruction that may pass through the pipe and lodge in the check valve, without necessitating a shutdown or the stoppage of the feed to the balance of the boilers. If globe valves are used for feed valves, they should be turned so that the discharge from the pump will be beneath the disk. This will prevent shutting off the supply of water from the boiler, should the disk become detached from the stem. When more important considerations do not interfere, the feed and check valves on a feed pipe should be placed as close to the point where the pipe enters the boiler as possible.

Under no consideration should the feed pipe connect two or more boilers together without the intervention of check valves, with the exception of heating plants, where the returns are fed directly to the boilers by gravity. Without check valves on such connection for power boilers, the water may be driven from one boiler to another, and cause a dangerous condition of low water to exist in some of the boilers. Fig. 18 illustrates an incorrect connection of this kind that is frequently met with in sawmills and similar plants. This is a dangerous arrangement, for under operating conditions, with the usual arrangement of steam pipes, sufficient differences of pressure may exist in the different boilers (although the steam valves are wide open) to cause a serious difference in the water level. If a main-stop valve is closed on one of the boilers without the feed valve being also closed, the water would be either forced out of this boiler, due to an increase in pressure above its mates, or it would entirely fill up by drawing water from the other boilers, should the pressure in it fall.

Automatic Feed-Water Regulators and Alarm Columns

These two devices are discussed under the same heading because they should go hand in hand and both should be looked after by a competent water-tender. It is absurd to say that all automatic devices are dangerous for use on a boiler, for a safety valve is automatic in action, yet no intelligent engineer would think of operating a boiler without its being equipped with such a safety device. It is a fact, however, that a boiler attendant after noting the repeated successful operation of an automatic device, begins to rely on its use and relaxes the watchful care he would otherwise bestow on the various devices. A possible answer to the question, Do automatic devices in a boiler plant pay? is that many of them enable an intelligent operator to handle more work with greater efficiency than could be done without their aid. They should never be used to aid a lazy or incompetent attendant to shun work.

Aside from safety valves and damper regulators, automatic feed-water regulators are the most common of the automatic devices used in connection with boiler operation. There are many kinds of feed-water regulators, all of which operate on the change of water level in the boiler, and since there must be some appreciable change in the water level, in order to sufficiently affect the buoyancy of the floats used to operate directly or indirectly the feed-controlling valves, the action is in reality intermittent and not constant.

A good illustration of the intermittent action of so called feed-water regulators, is shown in a pamphlet issued by the General Electric Co. on "Steam-Boiler Economy." A diagram showing the rate of feed entrance and steam output, taken over a period of practically an hour, shows that the feed water was admitted at a uniform rate of about 54,000 lb. per hour for an interval of three minutes, after which the feed would be automatically stopped with practically no admission for a period of nine minutes, after which another three-minute period of maximum feed flow would occur. No figures are given for the feed-water temperature, but the output from the boiler was decreased from a rate of about 24,000 lbs. of steam per hour as a maximum to 8000 lb. per hour. This drop in steam output occurred through a period of three minutes and lagged about one and a half minutes behind the feed period. After the lower limit was reached, the steam output increased at a uniform rate to the maximum. It can be seen from this data that such a regulator operating on a single boiler plant, if the plant was worked near its maximum capacity, might be a source of trouble instead of an aid to uniform operating conditions. If this kind of feed apparatus should operate in synchronism on several boilers, it would affect the ability of the plant to care for overloads.

The reduction of boiler capacity due to intermittent feeding has probably not been thoroughly appreciated by the average engineer, but the fireman has always known what a help it was to have the feed cut off while he was making a fight to gain on the steam pressure. It is probable that with a load that is at all steady, the best operating conditions are obtained by using a hand-controlled valve which bypasses the regulator, this valve to be so set that it will not quite supply the boiler with

the average amount of feed water required and allow the automatic valve to care for the deficiency. This arrangement will greatly lengthen the time intervals between the operations of the automatic valve, and consequently reduce the effect of its operation on the boiler performance. One regulator manufacturer has recently gotten out a regulator valve with such a bypass as part of the valve proper.

The absurdity of the claim made for the average feed-water regulator, that the apparatus maintains a continuous feed, can be readily appreciated when it is considered that the drop in water level of, say, a 250-hp. water-tube boiler (without the introduction of feed water) is only 0.15 in. per minute when operating at rating. A 100-hp., horizontal, tubular-boiler would change the water-line about 0.12 in. per minute, under the same conditions.

In installing a feed-water regulator the portion that contains the actuating float is placed near the boiler on a line with the proper water level in the boiler, and the feed pump is usually equipped with an automatic governor, which controls its action according to the pressure in the feed line. Some regulators operate so that the closing of the automatic feed valve is positive to prevent further entrance of feed water to the boiler, and no amount of pressure in the feed line will tend to cause the valve to open. With this equipment, if the pump governor fails to work from any cause and the cylinder ratios are large, a dangerously high pressure may be developed in the feed lines. The writer prefers regulators that do not close the inlet valve in this positive manner, but permit a leakage by the valve when certain differences exist between the boiler pressure and the feed-line pressure.

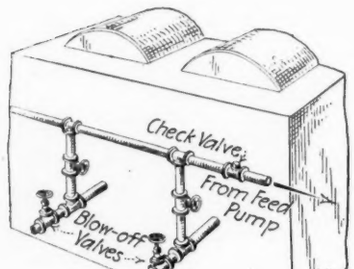


FIG. 18. INCORRECT FEED-PIPE CONNECTION

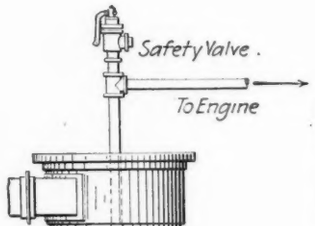


FIG. 19. FAULTY SAFETY-VALVE PIPING

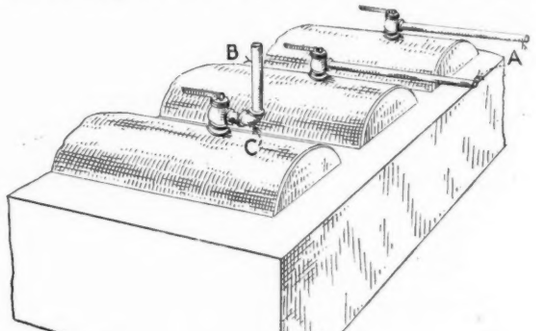


FIG. 20. VERTICAL AND HORIZONTAL DISCHARGE PIPES

No feed-water regulator should be used on a boiler without a low-water alarm column being also used; and this column and its connections to the boiler should be entirely separate and distinct from those to the regulator. It is a common expedient to reduce cost by combining these different pieces of apparatus in one, but this arrangement should not appeal to the engineer, for he should realize that the complete separation of these two pieces of apparatus is the only thing that can render one a real check against the other, and such a check is most necessary.

The low-water alarm column is, of course, used in the regular way as a water column and in addition it carries a float which operates a whistle to notify the attendant when the water level is too low. Alarm columns are usually made to notify the attendant when both high and low levels of water are reached, but the writer believes that it is much safer to limit the indications to low water only, for then there can be no mistaking what is the trouble when the whiste blows and the attendant is not required to make any distinction between tones. A number of accidents, particularly on vertical boilers, where the water columns could not be readily seen from the floor level, have been caused by the attendants blowing down a boiler, to relieve a condition of supposed high-water level, when he was in reality further emptying a boiler in which the water was already low. The only way to insure the satisfactory operation of automatic apparatus, is to be ever on the alert to discover any derangement, and this requires that its operation be tested frequently and at regular intervals.

PROPER ARRANGEMENT OF SAFETY VALVES

It is usually considered sufficient for all purposes of safety that a safety valve be attached to the steam space of a boiler without the intervention of a stop valve, and have the connections to the boiler and from the discharge side of the valve fully as large as the entrance port of the valve. The intelligent application of this very necessary safety appliance is, however, not such a simple matter. In the first place if a spring-pop valve is used, it is generally adjusted to be fairly sensitive; that is, it will perform all of its functions within a small range of pressure. On this account, when possible, a safety valve should be placed on a separate connection and not on the main steam outlet. If a boiler is only provided with one steam outlet, then the safety valve should be located as close to this outlet as possible.

When steam is used to operate a reciprocating engine, it is drawn from the boilers in puffs, instead of a steady stream, and under these circumstances variations in the pressure are constantly occurring in the pipe line. The variations in pressure are much more pronounced near the engine and less so near the boiler. Where a pop valve is located on a pipe line, away from the boiler, under these conditions, and the running pressure is near that for which the valve is set, the valve is liable to chatter and wear out the disk or seat in a short time. Fig. 19 shows an arrangement of this kind on a vertical boiler that gave trouble from this cause. The tee in this

case offers about the same resistance to the passage of steam as would be caused by 40 ft. of straight pipe and the variations in the pressure under the valve, due to the uneven draft by the engine, was sufficient to cause it to chatter badly whenever the steam pressure reached a point near that at which the valve was set. The flow of steam in a pipe leading to a safety valve and also in the connection leading from the exhaust side, can cause considerable pressure changes at the valve during its operation, and if these connections are too long or small they may prevent it working satisfactorily.

It is annoying, in the average plant, to have the valves discharge directly in the boiler room, so escape pipes are generally used to carry the steam outside. When it is possible the escape pipes should be placed in a horizontal position, as shown at *A*, Fig. 20, with a slight fall from the valves to the open end, so that there will be no tendency for water to collect in these pipes. It is not practical to have horizontal discharge connections in all cases and sometimes these pipes are run through the roof.

It is evident that care must be taken with such an arrangement, to prevent the collection of water in the discharge pipes. Nearly all pop safety valves have a small hole provided in them for this purpose, but they are usually too small to be trusted, and a 1-in. hole should be drilled in the bottom of each elbow at *C*, and even with a hole of this size it is necessary to watch it to prevent its becoming stopped with rust and scale. When the discharge pipe is not positively drained and water collects in it, the spring of the valve is ruined in a short time and the disk is liable to corrode fast to the seat, or scale may block the free space between the coils of the spring so that it is entirely inoperative; this condition is found with alarming frequency by boiler inspectors.

To insure that a safety valve is operative, its freedom of action should be tested daily by raising the steam pressure until the popping point is reached, but often this method of testing is objectionable, for some reason, and the valve must be tested by hand; to test by this this method, the testing levers should be kept in place at all times and not left detached, as is frequently the case after setting a valve. When the roof over the boilers is low, it is generally a hot, dirty place for the engineer to crawl to test the safety valves and on this account it is often neglected. A chain or rope, with suitable pulleys may be arranged so as to test the freedom of the safety valves from the floor level, but in putting up such a contrivance, every precaution should be taken to see that it will be impossible for it to in any way hinder the regular operation of the valve, particularly so, if it happens to be of the lever type.

The safety valves on all boilers connected to a common steam main should be set at approximately the same pressure, and this should be the pressure suited for the weakest boiler in the battery. Where boilers are capable of carrying varying pressures and the valves are not all set at the lowest pressure, the steam pressure may rise above that suitable for the weakest boiler in the event of the sudden stoppage of the flow of steam, because the valve area for the relief of steam at the low pressure would be inadequate.

The setting of a pop safety valve should never be changed without knowing for what pressure the spring was originally intended. A description of the spring, giving the inside or outside diameter of the coil, and with accurate dimensions of the cross section of the bar from which the spring was made, together with the length of spring and size of valve, if sent to the manufacturer of the valve, will bring forth the needed information. The danger of setting a pop valve without knowing for what pressure the spring was originally intended to be used, is that the spring may be too weak for the pressure desired and the coils compressed to a point where the free liberation of steam may be interfered with, if not absolutely prevented, as has often been found to be the case where inexperienced persons have attempted to readjust pop safety valves.

If the pressure is much less than that for which the spring was designed the valve will not operate satisfactorily. Generally a safety-valve spring is suited for a 10 per cent. increase or decrease in pressure from that for which it was originally intended, but it is never safe to assume that the pressure to which a valve is set is the one for which the spring was designed.

Some Power Features of the Ghent Exposition

Three years ago there was a large international exposition at Brussels. It ought to have been in 1908 and Ghent, only an hour's ride away, was to have one this year, five years later. Notwithstanding the postponement of the Brussels show and the short interval, Ghent has persisted in her determination to have the exposition this year as intended, and under the circumstances has produced a really creditable display.

The most striking exhibit in the power line is that of Carel Frères, of Ghent, whose activity in the development of the modern Diesel engine has given them an international reputation and led to an extensive enlargement of their works. Their exhibit occupies the center of Machinery Hall, and has for its most prominent feature a 1600-hp. reversible marine engine, carrying a large propeller upon its shaft, with thrust block and mountings just as it would be installed in a vessel. It is under the complete control of the operator and always attracts a large crowd when it is maneuvered. It is two-stroke-cycle, single-acting, with six cylinders, 510 mm. (20 in.) in diameter, 920 mm. (36 in.) stroke and is designed to run at 130 r.p.m. There are two double-acting, scavenging pumps run by levers from the main engine, and the Reavell compressor for the fuel-injection air is carried at the end of the shaft opposite that to which the screw is attached. The crankshaft is made up in three duplicate lengths so that only one spare has to be carried. The injection pressure is about 45 atmospheres and the scavenging pressure between 4 and 5 lb. There are four scavenging valves in the head of each cylinder, regularly disposed about the central fuel valve, directly behind which and between two of the scavenging valves is the air-starting valve. It is claimed that about 30 per cent. less in length of the vessel is required for such an installation than for engines and boilers, and that there is besides a considerable saving in weight as compared with the steam-driven plant.

The Carel Frères have also a four-cylinder, vertical, two-stroke-cycle engine of 1000 hp. connected to an al-

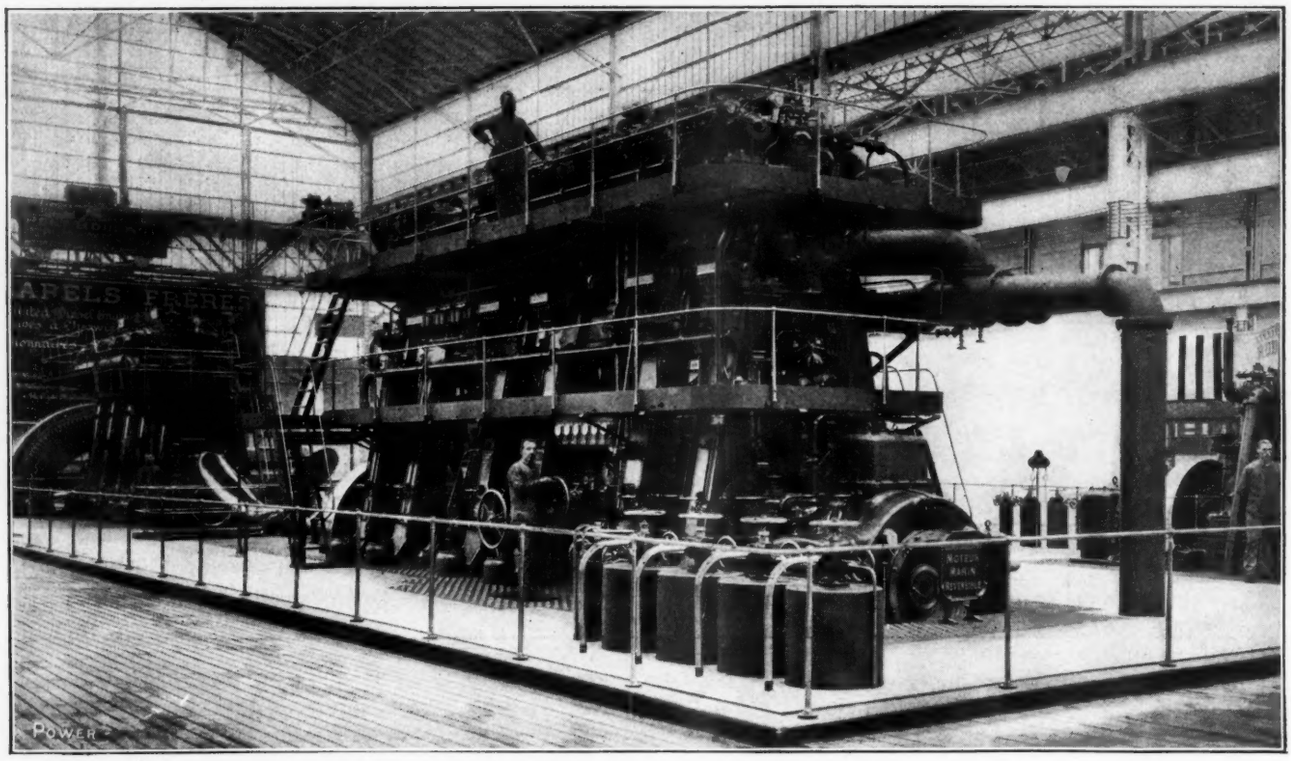


FIG. 1. TWO-STROKE-CYCLE MARINE CARELS ENGINE OF 1500 HP.

ternator furnishing current for the exposition. This runs at 160 r.p.m. and is much smaller than the marine engine in proportion to the power which it develops. It has a single scavenging pump in line with the other cylinders and operated by a crank from the main shaft, while the scavenging pumps of the marine engine are on the floor level and behind the main machine.

the four-stroke-cycle type and has a two-stage compressor operated directly from the crankshaft. They are producing a brake horsepower on about 190 grams (0.42 lb. prox.) of fuel oil per hour.

They exhibit also a 2500-hp. cross-compound steam engine, but it is a sign of the times that it is not in motion.

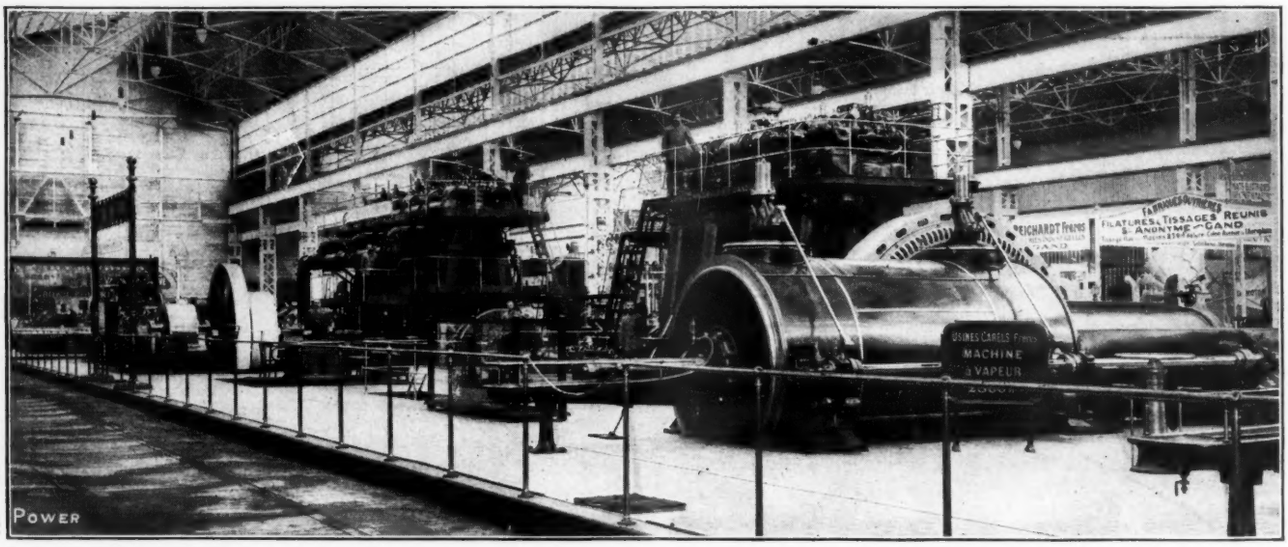


FIG. 2. GENERAL VIEW OF EXHIBIT

There is also shown an auxiliary compressor for the marine engine, two cylinders, vertical, four-stroke-cycle, 120 hp.

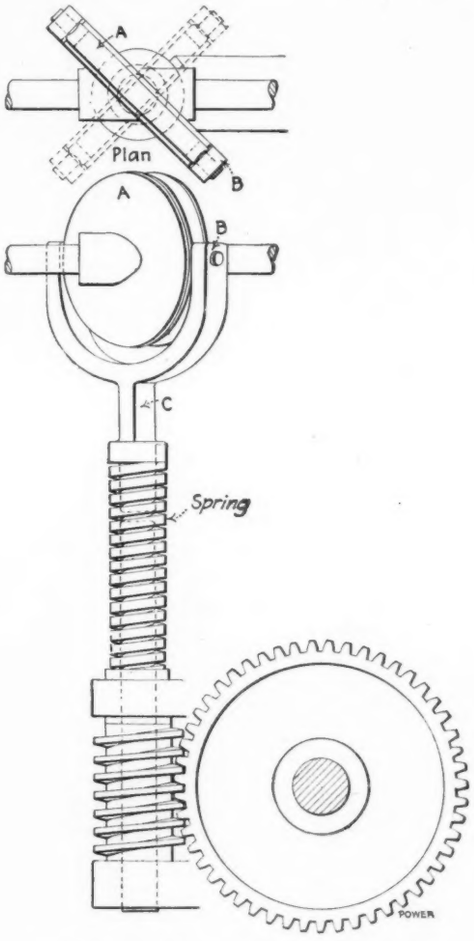
They have just developed a horizontal, single-cylinder engine, a 100-hp. example of which is shown. It is cheaper and more accessible than the vertical and the trunk piston can be taken out without removing the cylinder head by uncoupling the connecting-rod. It is of

Van den Kerchove, of Ghent, has two tandem-compound engines with his piston valves 500 hp. each at 150 r.p.m. and two Van den Kerchove-Bergmann turbines of 1500 kw., each running at 3000 revolutions. They have one Curtis wheel with two velocity stages and 10 Rateau or pressure stages. They are sold to the city of Ghent for its central station and help to supply current for the exposition.

An impressive exhibit is a Curtis runner for a turbine, some seven or eight feet in diameter and bearing the legend: "Capable of developing all by itself 3000 hp. at 1500 r.p.m." Its significance comes from its juxtaposition to the comparatively massive and complicated Diesel which develops only half as much. But the boilers and auxiliaries are not exhibited with the wheel.

An installation of Balcke or Le Blanc condensers is shown running in an open tiled condenser pit.

Brown, Boveri & Co. have a 2000-kw. unit running at 3000 r.p.m. and a smaller unit not in operation. They show also a surface condenser, one side of which may be opened and cleaned while the other side is in use.



ACTUATING DEVICE FOR CHAIN GRATE

Cockerill, of Seraing, shows a crankshaft weighing 85,000 kg. (187,000 lb.), 45,000 of which is shaft and 40,000 cranks.

The Société de la Meuse exhibit a turbine of 1250 kw. designed to run at 3000 revolutions.

There are a few small locomobiles, by French and Belgian makers, one in particular by Boulte, Larbodiere & Cie., Aubervilliers (Seine), is hardly a locomobile but with a vertical engine combined with a vertical boiler, superheater, etc., upon the same base.

Delaunay Belleville exhibits a boiler with an interesting mechanical stoker. Imagine the pulley *A* mounted obliquely on its shaft. As the shaft revolves the pulley will vibrate between the solid and the dotted positions. The pulley carries a ring *B* with pins to which is fitted the forked end of the shaft which operates the worm gear of a chain grate. This shaft is rotated backward and forward by the vibratory motion of the pins and carries at its lower end a spring incircling the shaft which carries the worm. As the shaft *C* turns in one direction it wraps the spring tightly around the worm shaft and carries it forward, while on the backward movement it tends to unwind and loosen the spring which slips backward around the shaft without turning it.

The largest transformers in the world are being built by the Siemens-Schuckert Co., at Nürnberg, for the Uberland central station, near Essen, Prussia. They are two in number of 24,000 kw. capacity, each 6300 volts primary, 25,200 secondary.

Purchasing Coal under Specifications*

BY GEORGE S. POPE†

In purchasing coal for any power plant the aim should be to obtain a fuel which, all things considered (such as equipment, price of coal, and cost of labor and repairs), will produce a horsepower for the least cost.

The purchase of coal by the government under specifications depending on the heating value of the coal, its content of ash and of moisture, and other considerations, rather than upon the reputation or trade name of the coal, was first adopted by the United States Treasury Department in 1906. Since then the plan, variously modified in form, but the same in principle, has been gradually adopted by other departments until at present, of the coal used by the government, the total value of which approximates $8,000,000 annually, more than half is purchased under specifications.

SUMMARY OF ADVANTAGES

The advantages of purchasing coal under specifications may be briefly summarized as follows:

1. Bidders are placed on a strictly competitive basis as regards quality as well as price. This simplifies the selection of the most desirable bid and minimizes controversy and criticism in making awards.
2. The field for both the purchaser and the dealers is broadened, as trade names are ignored and comparatively unknown coals offered by responsible bidders may be accepted without detriment to the purchaser.
3. The purchaser is insured against the delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on the usual visual inspection.
4. Experience with the old form of contract shows that it is not always expedient to reject poor coal, because of the difficulty, delay and cost of removal. Under the present system, rejectable coal may be accepted at a greatly reduced price.
5. A definite basis for the cancellation of the contract is provided.
6. The constant inspection and analysis of the coal delivered furnishes a check on the practical results obtained in burning the coal.
7. Payment in proportion to quality incites the contractor to prepare the coal more carefully.

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*Abstract of a paper read before the National Association of Cotton Manufacturers, at the 95th semiannual meeting, Atlantic City, N. J., Oct. 2, 1913.

†Engineer-in-charge of Government Fuel Inspection, Bureau of Mines, Washington, D. C.

Award of Contracts

In the purchase of coal according to its heating value and composition an important detail, which seems not to be thoroughly understood, is the manner of making awards. Awards should not be made solely on the chemical analyses and the heating value determinations in the absence of information of the behavior of the coals in practical service operation, for while calorific rating allows an award to be made to the best economic advantage, other factors may, under certain conditions, have considerable weight, especially if uncertainty exists as to the suitability or adaptability of an untried coal to the plant for which it is purchased, and the consideration of this question must take into account the type and condition of furnaces and grates, the draft, the labor of handling coal and ash, the storage facilities, etc.

Two coals having the same percentage of ash by analysis may behave very differently in the furnaces, for one may clinker and the other not, the ash by analysis not indicating the extent to which the ash may fuse or slag on the grate bars and thus seriously interfere with the capacity and efficiency of the plant. The relation of the composition of the ash to its liability to clinker is a matter which is being studied, but as yet altogether satisfactory results have not been obtained. On the other hand, clinkering is frequently caused by the firemen slicing the fire too often and working the ash up from the grates into the hot coal bed, where it melts and fuses into heavy dense masses.

The chemical analysis of coal may not indicate whether the coal will cake in the furnace, thereby interfering with the draft and lowering the rate and completeness of combustion.

Different coals with the same percentage of volatile matter may not behave alike in the furnace because the proportion of combustible and noncombustible constituents in the volatile matter, the character of the combustible constituents, and the temperature at which they are given off in the furnace, vary in different coals.

In the absence then of information on the results which may be obtained in actual service to supplement the chemical analyses and heating tests, it may prove difficult to determine the award to the best economic advantage and service tests in the plant equipment will be required.

In comparing bids on the basis of the chemical analyses and B.t.u. of the coal offered by the respective bidders, the method used is to merge the variables—ash, moisture, calorific value and price bid per ton—into one figure, the cost of 1,000,000 B.t.u. Any coals which have proved from experience or by practical test unsuited for the furnace and boiler equipment, or have failed to meet the requirements of the city smoke ordinances, may be eliminated from consideration regardless of their calculated costs per million B.t.u. and the remaining bids may be compared. The lowest bid then selected should be considered as a tentative award only, the final award to depend on the coal giving satisfaction in every respect in the plant equipment and on the satisfactory fulfillment of the contract.

The relative facilities, competency and responsibility of the competing firms must, of course, also be considered in making awards.

Government Specifications for Coal

Two classes of coal, anthracite and bituminous, are recognized and differentiated in government specifications. By anthracite is meant the coal mined in Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Sullivan, Northumberland and Dauphin Counties, Penn. By bituminous coal is meant varieties other than anthracite, including the several grades of semibituminous and sub-bituminous.

The bituminous specifications require the bidder to specify the quality of coal offered in terms of moisture, "as received," ash, sulphur, volatile matter and B.t.u., "dry coal"; these values becoming the standards of the contract to determine rejectable coal and the price to be paid for delivered coal.

The specifications allow a variation of 2 per cent. from the ash and heating value standards before making corrections in price. This is allowed to provide (*a*) for the reasonable variations in composition that, it is recognized, the same sample may show in the laboratory in two different determinations, (*b*) for variations that arise in preparing and reducing the gross sample collected from the delivery to a quantity convenient for transmittal to the laboratory, (*c*) for variations due to the collection of gross samples as representing the coal sampled, and (*d*) for allowing the contractor latitude in the preparation of the coal, since it is recognized that the quality of his coal as expressed in terms of ash and B.t.u. cannot be strictly controlled within narrow limits.

The specifications require the bidders to specify a maximum moisture content in the coal offered. This value becomes the standard of the contract. No price correction is made for deliveries containing by analysis a moisture content less than the standard, but the price is corrected for moisture in excess of the amount guaranteed by the contractor, the deduction being determined by multiplying the price bid by the percentage of moisture in excess of the amount guaranteed.

The fact is recognized that the amount of moisture contained in coal produced from day to day from the same mine, or group of mines working the same bed, is largely accidental, and is a matter over which the buyer and seller have only a slight control. However, in order to place a negative value on high-moisture coals and to protect the government against the delivery of coals containing excessive amounts of moisture, the bidders are required to guarantee a maximum moisture content. Price corrections on account of excessive moisture are seldom necessary if the contractor does not guarantee a content lower than can be actually maintained on an average.

No corrections in price are made for variations in volatile matter, for the government does not consider any scheme of applying penalties on account of such variations to be equitable.

The results of tests and experiments show that the percentage of sulphur does not indicate the behavior of the coal in the furnace. For a long time it was thought that the sulphur formed clinker, but investigations point to the fact that sulphur is not the only cause of clinkering; in fact, there may be no difficulty from clinker in burning coal containing as much as 5 per cent. or more sulphur. The relative proportions of iron, sulphur, lime, alumina, silica, etc., in the ash affect its fusibility, where-

as the method of firing and the rate of combustion are important factors in the formation of clinkers. At many power plants the fireman slices the fire too often and works the ash up from the grates into the hot coal bed, where it melts and fuses into heavy dense masses of clinker. At high rates of combustion the ash in a given coal may clinker (though at lower rates it does not), because of the ash being raised to the fusing temperature. Because of these variables no corrections in price for variations in sulphur are made under government specifications, but the contractors are required to specify the sulphur content so that standards for the coals to be delivered may be established.

Many commercial and municipal specifications exact penalties for a slight increase in the sulphur content, although coal of high sulphur content may clinker less and its heating value may be higher. One specification received by the Bureau of Mines exacts a deduction of 5 per cent. in price for each 1 per cent. of sulphur in excess of the standard. In the case of a coal supplied at $3 per ton, the presence of 1 per cent. of sulphur in excess of the standard, as indicated by analysis, would often result in an unwarranted deduction of 15c. a ton. Under such a contract, the variations which are recognized to exist in sampling and analysis may cause a contractor unjustly to suffer a heavy deduction.

Both the sulphur and the volatile-matter content should be used to classify coals and to identify the coal guaranteed. Variations indicating the substitution of an unsatisfactory coal should be considered cause for rejection of the coal or for cancellation of the contract.

For the purchase of the domestic sizes of anthracite coal, the government has established a standard of ash content for each size. Coal containing ash in excess of a maximum limit is subject to rejection and to removal by the contractor at no cost to the government, or if used it is subject to a deduction in price. B.t.u. standards are not used, as it has been determined that the heating value for the different sizes is, in the main, a function of the ash content, varying inversely and in proportion with the ash; that is to say, if the ash content is increased, for example, 1 per cent., the heating value is decreased 1 per cent.

The power-plant sizes of anthracite may be purchased either under the specifications which are used for bituminous coal, the bidder guaranteeing the heating value, ash, moisture, etc., or under specifications similar to those for domestic sizes, wherein a standard of ash or B.t.u. or both is established.

Sampling

The method of taking and preparing samples for shipment to the laboratory has been given fully as much care as the making of the analyses and tests. The method employed is to select portions from all parts of a consignment or delivery of coal and to systematically reduce the gross sample, obtained by mixing these portions, to quantities that the chemist requires for making ash, and other determinations, or that can be burned conveniently in the calorimeter, an apparatus for determining the heating value. The gross sample should be so large that the chance admixture of pieces of slate, bone coal, pyrite, or other impurities in an otherwise representative sample will affect but slightly the final results. Increasing the size of the gross sample tends toward accuracy, but the possible increase is limited by the cost of collection and reduction. In reducing the gross sample by successive crushings and halvings or fractional selections, the object is to procure a small laboratory sample that, upon analysis, will show approximately the same composition as the gross sample itself, or, in fact, as the entire quantity of coal from which the gross sample was obtained.

The method of sampling is very often given scant mention in specifications and contracts, thereby leaving one of the most important features determining the successful and satisfactory application of the specification method of the purchase of coal almost wholly in the hands of the purchaser, the seller having little or no means whereby he can exercise a control of the manner and method of collecting and preparing samples that should represent the coal furnished. Because of its importance, government specifications give in considerable detail the method of sampling.

The best opportunities for procuring representative samples are afforded while the coal is being unloaded from railroad cars, ships and barges, or while it is being dumped from wagons. Samples collected from the coal exposed in piles, bins, barges or ships can be considered representative only under the condition that the mass of coal is homogeneous throughout. Such a condition is highly uncertain and even improbable, and the analysis of samples collected from the surface may give results that are very unreliable as indicating the nature of the entire quantity, and that may be worthless as a basis for determining an equitable price to be paid for the coal because when sampled in this manner errors of the personal equation factor are multiplied.

The preparation of a gross sample for shipment to the laboratory involves three operations: (1) crushing, (2) mixing and (3) reduction in quantity. The operations must proceed in stages according to a prearranged plan and in a systematic manner until a final sample of about 3 lb. is obtained. This 3-lb. sample should be placed in a container and sealed air-tight and forwarded to the laboratory for analysis.

The advantages of definite specifications for purchasing coal, the results obtained from the method, together with the analyses and tests of coals delivered under government contracts during the fiscal year 1909-10, are published in Bureau of Mines Bulletin 41, "Government Coal Purchases under Specifications." Directions for sampling and types of specifications are given in Bureau of Mines Bulletin 63, "Sampling Coal Deliveries and Types of Government Specifications for the Purchase of Coal."

Duties of the Marine Engineer—The chief engineer is held responsible for all the machinery on board. Apart from the main engines, the auxiliary machinery includes the following: Windlass gear for heaving the anchor, capstans, warping engines, winches and steering gear, refrigerating and condensing plant, air circulating, feed, fresh water, sanitary and other pumps, and miles of piping of all sizes. The electric plant alone is capable of supplying power sufficient for a town of 20,000 inhabitants. Fans supplying air to the different parts of a ship for ventilating purposes are all motor-driven, and the air being regulated in temperature before entering the compartment, serves the double purpose of being used for both heat and ventilation. This system also comes under the chief engineer's care. There are over 80 auxiliary engines on board some boats, besides an extensive plant in connection with the water-tight doors, controlled from the bridge. All water-tight doors can be closed in an instant in case of accident.—"Marine Review."

Record of Pasadena's Municipal Plant*

SYNOPSIS—With a graduated rate of 5 to 3c. for lighting and 4 to 1.2c. for power the plant earned 8.18 per cent. with an annual output sold of 3,154,883 kw.-hr. Basing the saving over the old rates before municipal ownership, the plant has paid for itself in five years.

In 1907, Pasadena, Calif., installed a municipal plant which has been remarkably successful and has furnished current for power and lighting at exceptionally low rates. Annual reports have been issued from the time of its inception, and some of these have been given space in POWER. The sixth annual report for the year ending June 30, 1913, is now available, and gives some very interesting data on operating records and costs.

It will perhaps be well to enumerate the equipment of the plant before giving a summary of the operating records. The plant has been equipped with 1100 hp. in boilers of the B. & W. and Stirling types, and a new 400-hp. boiler is now being installed. There are 2000 hp. in cross-compound condensing engines, and 2000 hp. of Parsons steam turbine, making a total generating capacity of 4000 hp. The number of service connections totals 6556, and the idle service connections 1779. The total connected three-phase motor load is 2036 hp., and besides there are 326 hp. in single-phase motors, so that the total power load is 2362 hp. The street-lighting system consists of 278 inclosed arc lamps, 3259 tungsten lamps of various ratings, and 222 ornamental lights. The area of the city is 11.2 square miles, and there are 150 miles of streets.

According to the financial data given in the report, the undepreciated value of the plant is $608,028.04. The net value of the plant depreciated is $504,564.98, and adding to this the cash on hand, accounts receivable, and the inventory of construction material and supplies on hand, makes the total asset value of the plant $541,400.35.

From the output report, it will be noted that the total current generated amounted to 4,022,230 kw.-hr. The manufacturing cost of all current generated amounted to $0.00916, the distribution cost $0.00826, the interest $0.00516, and the depreciation $0.00610, making a total of $0.02868 per kw.-hr. On the basis of current sold, the total cost per kilowatt-hour increases to $0.03656.

OUTPUT REPORT

Output in Kw.-hr. for Year Ending June 30, 1913

Street Lighting	Kw.-hr.	Receipts	Receipts per Kw.-hr.
Clusters and alleys	216,090	$7,249.93	$0.03355
Arcs and series tungstens	654,750	38,462.00	0.05874
	870,840	$45,711.93	0.05249
Commercial System			
Lighting (including city bldg.)	1,557,999	$74,138.80	0.04759
Power	726,044	19,038.68	0.02622
	2,284,043	$93,177.48	0.04079
Total sold	3,154,883	138,889.41	0.04402
Lighting at plant	24,229		
Lighting at stockroom and office	11,777		
Testing lamps	715		
	36,721		
Light loss, or unaccounted for current	830,626		
Total current generated	4,022,230		
Received for all current generated			$0.03453
Received for all current sold			0.04402

*From sixth annual report of Pasadena's Municipal Lighting Works Department, by C. W. Koiner, electrical engineer and general manager.

	Mfg.	Dist.	Int.	Dep.	Total
Cost of all current generated	$0.00916	$0.00826	$0.00516	$0.00610	$0.02868
Cost of all current sold	0.01168	0.01054	0.00657	0.00777	0.03656
Kw.-hr. per bbl. of oil					131.85
Efficiency of distributing system, per cent					78.44
Load factor, as per peak load, per cent					28.69
Load factor, total for amount of machinery, per cent					15.05
Revenue per kw. station capacity					$45.54

The operation account includes earnings and expenditures. The accompanying summary will no doubt be of interest.

OPERATION ACCOUNT

	1912–13	1911–12
Earnings		
Street lighting	$45,711.93	$40,714.45
Commercial light and power	93,177.48	82,770.66
	$138,889.41	$123,485.11
Expenditures		
Manufacturing:		
Fuel oil	$22,998.41	$22,371.37
Lubricants	1,176.63	1,339.74
Wages at station	7,306.86	7,040.93
Water at station	33.35	148.95
Miscellaneous manufacturing supplies	882.39	1,727.90
Repairs to building	182.07	356.16
Repairs to steam equipment	3,807.31	2,852.13
Repairs to electric equipment	453.80	440.54
Total manufacturing cost for year	$36,840.82	$36,277.72
Total distribution cost for year	$17,148.30	$13,746.83
Total general cost for year	$16,084.33	$13,675.75
Total	$70,073.45	$63,700.30

At the time of the inauguration of the plant, a base rate of 12½c. per kw.-hr. was charged for the first 666 kw.-hr. While this rate was lowered to meet the 8c. rate established by the city for current supplied to its municipal plants, the 12½c. base rate continued in force in various other southern California cities supplied by the company in competition with the city of Pasadena. Ultimately, the base rate in some of the various other cities was reduced to 10c., until Jan. 1, 1913, when a base rate of 8c. was established. In all probability, however, if it had not been for the example set by the people's plant in Pasadena, the other southern California cities would not now be enjoying an 8c. base rate. The facts are that the difference between the 8c. rate charged in these other cities and the 5c. rate charged by Pasadena's municipal lighting plant shows that there is a difference of 37½ per cent. in favor of municipal ownership, as against regulation. Or, to put it in another way, the consumers in other cities, outside of Los Angeles, pay 60 per cent. more than the consumers of the Pasadena municipal plant.

Pasadena claims a saving of not less than $408,000 from Oct. 1, 1908, to June 30, 1912, as a result of the establishment of its light and power works. To this should be added the saving resulting for the year ending June 30, 1913, which, if compared on the same basis of the old rate, would be not less than $223,625.96, and if figured at a maximum rate of 10c. for six months, and a maximum base rate of 8c. for six months, according to the rates paid by some of the other southern California cities, the saving would be not less than $149,083.96, making a grand total, when figured in the first way, of $631,625.96, and when figured in the second way, of $557,083.96.

There has been a great saving in the cost of street lighting as compared to the rates formerly paid by the city to the competitor of the municipal plant. Street arc lamps now cost 23 per cent. less; incandescent street lighting, 40 per cent. less, and ornamental cluster light-

ing at least 20 per cent. less than formerly paid. At the time the city began lighting its streets it had only the benefit of 50,000 cp. for street lighting, for which it paid $15,808.40. At the present time the city has 267,500 cp., or 4⅓ times more light, for which the city paid the past year $45,711.93. Another great advantage that must not be overlooked in making this comparison is that the service rendered for street illumination is far superior to anything the city had before it began illuminating its streets from its municipal plant. From the above, it is plainly evident that Pasadena, by reason of the difference in electric rates, has saved sufficient during the last five years to pay for the entire plant.

Details of the rates for lighting and power will no doubt be of interest, and are therefore included in the following:

SCHEDULE OF LIGHTING AND POWER RATES

Street Lighting

Arc lamps, 6.6 amp., $60 per annum.
40 cp. tungsten, 6.6 amp., $12 per annum.
80 cp. tungstens, 6.6 amp., $24 per annum.
250 cp. tungsten, 6.6 amp., $48 per annum.
350 cp. tungsten, 6.6 amp., $60 per annum.
Cluster posts, 3c. per kw.-hr., plus lamp renewals.

Incandescent Lighting

Class A—The first 100 kw-hr., or less, of energy furnished in any one month to any consumer, 5c. per kw.-hr.

Class B—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 500 kw.-hr., 4½c. per kw.-hr.

Class C—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr. and not exceeding 1000 kw.-hr., 4c. per kw.-hr.

Class D—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1000 kw.-hr. and not exceeding 2000 kw.-hr., 3½c. per kw.-hr.

Class E—The kilowatt-hours of energy furnished in any one month to any consumer over 2000 kw.-hr., 3c. per kw.-hr.

Arc Lighting

Class A Arc—The first 100 kw.-hr., or less, of energy furnished in any one month to any consumer, 4.9c. per kw.-hr.

Class B Arc—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 500 kw.-hr., 4½c. per kw.-hr.

Class C Arc—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr., 4c. per kw.-hr.

A minimum monthly charge of 60c. per meter of 3 kw. capacity or less, and 30c. for each additional kilowatt of meter capacity required, shall be made for each meter.

All energy furnished through or measured by a meter used for any incandescent lighting shall be paid for at incandescent lighting rates.

All energy furnished through or measured by a meter used for measuring energy used in arc lighting and not for any incandescent lighting, shall be deemed arc-light energy.

Upon request of consumer separate meters will be furnished for incandescent lighting, arc lighting and power and heat purposes.

Carbon and Gem lamps of such candlepower as the department can conveniently carry shall be furnished free for renewal purposes to all consumers.

Power

From and after Feb. 1, 1913, and until changed by the council of the city of Pasadena, the rates for electric energy furnished by it for power, heating or purposes other than lighting, shall be as follows:

Class A Power—The first 100 kw.-hr. of energy or less, furnished in any one month to any consumer, 4c. per kw.-hr.

Class B Power—The kilowatt-hours furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 300 kw.-hr., 2.4c. per kw.-hr.

Class C Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 300 kw.-hr. and not exceeding 500 kw.-hr., 2.4c. per kw.-hr.

Class D Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr. and not exceeding 1000 kw.-hr., 2c. per kw.-hr.

Class E Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1000 kw.-hr. and not exceeding 1500 kw.-hr., 2c. per kw.-hr.

Class F Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1500 kw.-hr. and not exceeding 2000 kw.-hr., 1.9c. per kw.-hr.

Class G Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 2000 kw.-hr. and not exceeding 3000 kw.-hr., 1.8c. per kw.-hr.

Class H Power—The kilowatt-hours of energy furnished in any one month to any consumer over 3000 kw.-hr., 1.2c. per kw.-hr.

A monthly minimum charge will be collected for electrical energy of $1 per meter of 1½ kw. capacity or less and $0.75 for each additional kilowatt of meter capacity required.

To Retire the "Imperator" from Service?

According to a German dispatch, "the Hamburg-American Line, in spite of earlier denials say that the boilers of the 'Imperator' have proved unsatisfactory, and that complete rebuilding is necessary in order to reduce the excessive coal consumption and to increase the speed of the vessel."

It is said that the builders by their contract were required to compensate the company for the compulsory retirement of the "Imperator" from service, and will have to pay about $1500 for every day she is laid off.

Technology Club Honors Prof. Sweet

The Technology Club, Syracuse, N. Y., on the occasion of its 11th annual meeting honored Prof. John E. Sweet, one of its founders and first president, by establishing the John E. Sweet lecture fund.

The fund, intended as a permanent testimonial to the venerable engineer, educator and inventor, is to be used for the maintenance of a lecture course in which distinguished speakers on both technical and popular subjects will be brought to Syracuse each year. The first lecture for 1913-14 will be given about Nov. 1.

The club has elected the following officers: President, James P. Barnes; second vice-president, Glenn D. Holmes; secretary, A. R. Acheson (reëlected); treasurer, M. B. Palmer (reëlected); directors for two years, Arthur J. Briggs and Harvey N. Smith.

Staten Island Boiler Explosion

Six people were killed and four injured by the explosion of a boiler in the Livingston station of the Richmond Light & Railway Co., Staten Island, N. Y., about 4:30 p.m., Tuesday, Oct. 21. The boiler which exploded was a Wickes boiler in a battery of three installed in 1901. It was projected upward through the roof almost vertically and came down bottom first in the Kill Von Kull. Except for damage to the brick work the other two boilers in the same battery were uninjured. The pressure carried was 180 lb. The bottom head of the lower drum was found among the débris in the basement and showed the failure to have occurred in almost a perfect circle where the curvature changed to form the flange. The coroner and the Public Service Commission intend to make a thorough investigation into the accident and we expect to be able to present further details in a subsequent issue.

As a consequence of the explosion most of Staten Island was without electric light that night and only a few cars were without electric light that night and only a few cars were running such as could be operated with the current supplied by the company's smaller station at Concord.

PERSONALS

De Witt Smith, formerly of Meriden, Conn., has been appointed chief engineer of the plant of the Trenton & Mercer County Traction Corporation, Trenton, N. J.

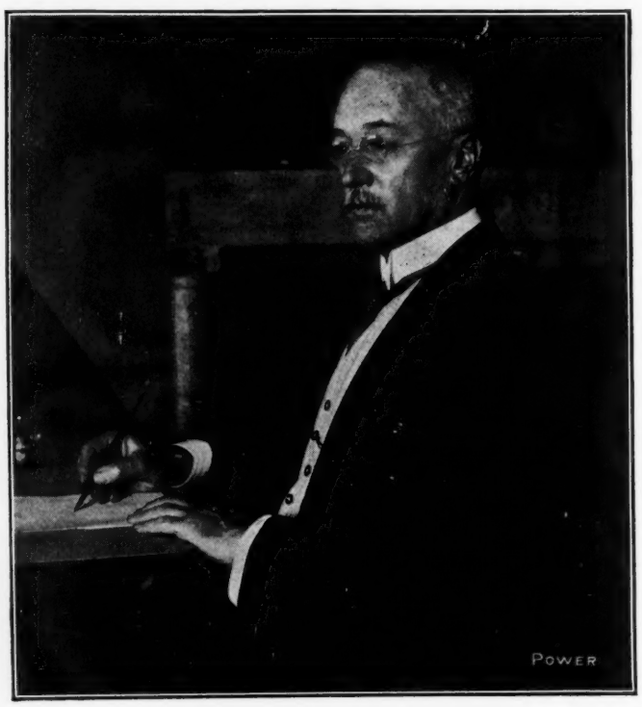
Hudson Dickerman, of the Johns-Pratt Co., Hartford, Conn., who had the misfortune to lose both hands in a roller at the mill, is recovering, and hopes to be on the road in the near future. Mr. Dickerman's host of friends will be delighted to know that he will regain his health and once more be about.

OBITUARY

RUDOLF DIESEL

Dr. Rudolf Diesel, the German engineer, famous through the invention of the type of engine which bears his name, disappeared from a steamer en route to Harwich, England, from Antwerp, on the night of Sept. 29. His body was found in the River Scheldt, more than a week later. His untimely death, and the mysterious circumstances surrounding it, just at a time when his invention was assured of success, caused a stir throughout the whole mechanical world.

Dr. Diesel was born of German parents, in Paris, in March, 1858, and commenced his elementary education in Paris schools. When the war of 1870 broke out, his parents went to England, and shortly after their arrival they sent their young son to Augsburg. After courses of study in the Augsburg technical schools, young Diesel entered the Munich



DR. RUDOLF DIESEL

Technical College, where he was graduated in 1879, and became assistant to Prof. von Linde. He then spent a short time in practical work at Messrs. Sulzer Brothers' works, Winterthur, on leaving which he was appointed manager of the French company for the manufacture in Paris of the von Linde refrigerating machinery.

The deceased engineer had from his student days been engrossed with the idea of discovering a prime mover having a much higher thermal efficiency than the steam engine, and in 1893 he described in his book, "Theorie und Konstruktion eines rationellen Wärmemotors," the engine he had designed. Dr. Diesel's theories attracted great attention in Germany and throughout the whole world, with the result that he was afforded financial aid by Messrs. Krupp and the Augsburg-Nuremberg Co. for the construction of an engine of the type he advocated. The first Diesel engine, a vertical stationary one, was built in 1893. This was on the four-stroke-cycle principle, the piston driving the shaft by a piston-rod and an external crosshead. The cylinder was not water-jacketed. A feature of this first engine was the low camshaft, resulting in the provision of long rods for operating the valves. The starting storage-chamber consisted of a wrought-iron pipe having riveted flanges; there was no air-supply pump, and the fuel was injected directly. This engine could never be made to run. It was driven by outside power, and at the first injection of fuel, as Dr. Diesel remarked, an explosion occurred, the indicator broke up, and pieces from it nearly killed the inventor. The occurrence showed, however, that pure air could be compressed to such a degree that it could ignite the oil fuel.

The second engine, built immediately afterward, had a water-cooled cylinder, and its camshaft was fitted higher up; its main difference, as compared with the first, was in the provision of an air-supply pump for injecting the oil fuel. This second engine did not run to any extent, and its working was attended with much danger. With it, however, Dr. Diesel was able to obtain a few indicator diagrams of the whole cycle. This engine confirmed the practical possibility, shown by the first, of initiating combustion by compressed air, which the inventor had shown to be theoretically possible

The first reliable Diesel engine, the third attempt, was built on Diesel's designs by the Augsburg Co., in 1897, after the inventor had carried out a series of experiments over a period of four years with the second engine. The third engine was of the vertical one-cylinder stationary type on the four-stroke-cycle principle, developing 18 hp.

In the years that followed several types were experimentally developed and Dr. Diesel continued to incorporate improvements with each successive engine. It might be said that the Diesel principle was soon found to be most applicable to a two-stroke-cycle engine, scavenging being carried out with pure air, and not with a fuel-air mixture, there being thus no risk of premature ignition and no fuel losses.

When last year Dr. Diesel put before the profession the history of his engine, he stated that the two-stroke-cycle was then, in 1912, on almost an equal footing with the four-stroke-cycle type, adding that this latter had a better combustion, more economical fuel consumption, and was simpler in its method of working. The four-stroke-cycle, therefore, remained the standard engine for medium-size stationary plants. The two-stroke-cycle engine, on the other hand, had smaller cylinders, and had come into favor for stationary plants of higher power; this latter engine seemed also to be, according to Dr. Diesel, the standard type for ship propulsion.

The first Diesel engine for ship propulsion was built in France, in 1903, by Messrs. Adrien Bochet and Frederic Dyckhoff, in conjunction with Dr. Diesel. The first marine Diesel engines were not reversible; they drove electric generators, and this made it possible to reverse the direction of rotation of the propeller. The first direct-reversing marine Diesel engine, working on the two-stroke-cycle principle, was built by Sulzer Brothers, Winterthur, in 1905.

Many builders have been for the past two or three years contemplating the construction of Diesel engines of high power for the propulsion of battleships and cruisers.

The latest application of the Diesel engine is for railway traction purposes, developed and built at the Sulzer Bros. plant. Dr. Diesel's patents for Great Britain were in the hands of the Consolidated Diesel Engine Manufacturers, Ltd., with new works at Ipswich, while the American rights formed the basis for the organization of the Busch-Sulzer Bros.-Diesel Engine Co., with new works in St. Louis, Mo.

CHARLES TELLIER

Charles Tellier, the inventor of the cold-storage process, who was reported a few days ago to be dying in want, died on Oct. 19, at the age of 85. His misery was relieved by subscriptions raised for him by the Cold Storage Co. a short time before his death.

Mr. Tellier discovered the present method of refrigerating meat some 30 years ago and celebrated the occasion by taking a number of friends on a vessel on which all the viands served had been preserved by his system. He built a number of works, but like most geniuses he never could save any money. He had one son, a delicate youth of 22, who seemed to be his whole care.

SOCIETY NOTES

The offices of the New England Association of Commercial Engineers have been moved to the Equitable Building, 67 Milk St., Boston, Mass.

At the regular meeting of the Louisiana Engineering Society, held on Monday, Oct. 13, in Gibson Hall, Tulane University, New Orleans, an illustrated paper, "Recent Developments in Evaporation," was read by A. L. Webre, engineer of the J. H. Murphy Iron Works.

The Detroit Engineering Society, on the evening of Oct. 3, gave a smoker and new members' night, at which 46 new members were admitted. About 200 members and friends listened to an informal talk by R. D. Follett, secretary of the Detroit Zoological Society on "The Aesthetic Side of the Conservation Problem." It was illustrated by a most interesting series of colored motion pictures.